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REPORT OF INSPECTION TRIP TO FRANCE, ITALY, GERMANY, HOLLAND, AND ENGLAND, MADE DURING THE WINTER OF 1921-1922

TECHNICAL SUPPLEMENT

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By

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RÉSUMÉ OF FRENCH RESEARCH, DEVELOPMENT, AND SERVICE AIRCRAFT.

French experimentation is concentrated on development of all-metal types and, unquestionably, metal construction is the keynote of French development to-day. The requirement that all their airplanes shall be capable of being stored indefinitely under any weather conditions without major harm has had much to do with the dominance of metal construction.

The principal research work that is being conducted by the aerodynamic section is in the development of efficient internally braced airfoils, investigations in stability and in the controllability of aircraft, more accurate determination of scientific data for mathematical design of propellers, investigation of the most efficient control surfaces, the problem of developing suitable methods of effecting mechanical control for large multimotored airplanes as an aid to the pilot, investigations as to the influence of interference in all types of aircraft, the accurate determination of correction factor data for application from wind tunnel models to full-scale work, and the exploration into the question of the influence of very high velocities in correct mathematical interpretation on general airplane properties.

The future French training types will be studies in all-metal construction. The Gourdou monoplane is a very representative type of French single-seater pursuit, although it is underpowered to meet the new pursuit requirement. The fuselage, landing gear, and tail surfaces are duralumin tubing with steel fittings, very similar to the Breguet type. Biplace pursuit and reconnaissance types can be realized with the 500-horsepower engine, but inasmuch as this necessitates a very heavy machine, the French have so far confined themselves to lower-powered motors equipped with superchargers to obtain high performance at altitudes with less structural weight.

Detachable tanks are considered very much better than the rubber-coated tanks where it is possible to use them. Most of the French types have been designed and laid out for long-distance work of an offensive nature. They require a large amount of gas in order to fulfill their missions. The French have stipulated that the excess gas to be carried for the cross-country passage to combat points may be placed in removable tanks to an average extent of about one-fourth of the total amount of fuel required. The position installation of these removable tanks, however, has not been stipulated. It is understood that they are to be placed on the outside of the machine so as to reduce the cubical capacity of the fuselage. This will be an advantage in procuring more efficient aerodynamic outline and partially removes the restraint and embarrassment as to disposition of equipment, accessories, and fuel within the airplane proper.

It is significant to note that one of their most important requirements for their two-place, armored machines is that they be capable of making a figure "eight" between two points situated 100 meters apart. The fact that this must be done at an altitude of 100 meters is a criterion of the ability of this machine to maneuver for position. The French require that pilots' seats shall, in all types, be capable of being regulated in height, and armored seats are provided wherever possible. Silencer apparatus is to be applied on all their night bombardment ships.

Twin-motored types of bombardment ships have been absolutely discounted by the French air service. They have stipulated that all their future multimotored machines shall be of three or four motors and capable of flying on one-half or, at most, two-thirds of their horsepower. Self-starters are to be provided on all their night ships and the propeller flanges equipped with adapting clutches for field starting. All their new machines are designed with provision for self-starters from the cockpit. Their representative field starter in service to-day is the Odier type. We have a sample of this starter at McCook Field.

The colonial type airplane (specifications attached) is to be of such design that it can be easily transformed to a bombardment ship. It will be multimotored and will carry a minimum of eight persons. Specifications governing this type are very interesting. They evidence the attention that is being given to the development of this special type for distant work in the colonies and for use under adverse climatic conditions. They are able to operate at great distances with heavy bomb load.

On all pursuit planes having fixed gun installations the cowling immediately around the gun mounting must be easily removable and provided with fasteners which can be adjusted quickly. Under no conditions will they permit the cowling to be bolted down. The modern tendency governing bomb installations is favoring the internal bomb rack for most of their machines where the size of bombs does not place a limitation on the initial structural layout. For their larger bombs they still use external supports.

Communication between pilot and observer must be by voice without the use of an aviophone. Where this is absolutely impossible, a passageway facilitating direct communication between pilot and observer is required. Crews are no longer permitted to be placed as in the Salmson types. Parachutes must be provided for all the personnel in all their types.

Another important requirement is that power plants must be completely changed in eight hours with two mechanics. Their gasoline pumps must be designed to feed any one or two of their motors. Starting of the

motor by hand or whirling of the propeller is to be absolutely discounted on all types. The specifications as to fuel supply requirements for all their different types are interpreted in terms of sea-level consumption so as to facilitate an accurate understanding with designers as to actual amount of gas required on all their types. The development of propellers to resist all extremes of climatic conditions is being pushed and will be provided on all their types as soon as possible.

Experimentation relative to the development of suitable duralumin floats is being conducted with their seaplane work. Deck landing trials are being made regularly with the idea of developing means to retard the progress of the airplane on landing and to provide the best methods to prevent the plane from going over the side of the ship. Their idea as applied to their ship planes to date has been the use of a hook attachment, about 10 feet long, fastened to the underside of the fuselage, immediately back of the landing gear. It can be dropped by the pilot and its rear extremity engages the ropes that are set transversely across the deck. These are fastened to sandbags. This method does not produce a very marked shock to the machines, owing to the leniency of resistance produced by moving the sandbags. Shock-absorbing devices in the forward extremity of the long metal hook are fastened to the underside of the airplane fuselage.

The French have been attaching considerable importance to the development of very high speed racing aircraft such as has been evidenced in the Nieuport Delage Sesquiplan. One of the main objects is to ascertain from trials in full scale the relation between the performances realized and theoretical performance advance rom laboratory experiments. It is their desire to determine standard correction factors that will be applicable in full-scale tests and to determine the value of different air foils and resistance factors at high velocities.

Preparing for and conducting racing meets is very expensive, but the benefits to be derived for general technical aeronautical purposes are of great value and open up technical research and center attention in a new domain in which everybody is more or less concerned. The development of pursuit is in a large measure dependent on the development of speed machines.

A brief reference to the work of the leading companies in France will give an indication as to the trend of opinion and development in French aeronautical circles. These references are necessarily brief in a résumé of this kind. but complete details covering the ships referred to will be found in another part of this report.

The Spad Co. is still developing monocoque construction and attribute their faith in it to the superior aerodynamic outlines that can be obtained. They have procured superior performance both in endurance and speed for a given period. Their new single-seater, high-altitude, pursuit type, and their new two-seater, high-altitude, pursuit and observation type in monocoque will be completed soon and should be followed closely. The performance and ultimate function of these two machines represent the overcoming of inertia of development on these two particular types. They have been found desirable by the French for pursuit and are being built to type specifications in experimental fashion. Full description of these machines will be found under the proper heading.

The Spad "Side-by-Side" training type is another radical departure for instruction purposes. The trend of opinion in American and European aeronautical training circles should be derived and conclusions drawn from it as to the desirability of this type for our ultimate training program. It is probable that a conclusive opinion may be reached in short order by our experience with the new two-seater Dayton-Wright training type which has just been completed and submitted for test.

The Nieuport Co. is still sticking to monocoque construction, and inasmuch as they have been endeavoring to attain the utmost in streamlining, they consider that this type construction is best adapted to attain the higher degree of fineness that is necessary. The performance obtained during the last four years with the Nieuport 29 has been sufficient evidence of the correctness of their theory. This machine is probably the best and most highly developed pursuit ship in the world.

The Breguet Co.'s interpretation of all-metal construction in their single-motored types is practically the same as they have used for the last four years and has been giving entire satisfaction. It is truly representative of French all-metal standard type construction and satisfactorily stood the test of service conditions in the World War. It is still being developed and used by the French air service. The type of construction used in the Breguet Leviathan represents a departure from the orthodox method, but is too complicated to be practical.

The Potez Co. has been working on a different adaptation of metal construction in their later models. They are principally prototypes of some of their earlier machines. Their master construction ideas are principally toward the use of duralumin shapes, such as channels and angles with gusset-joint construction as their characteristic interpretation. Very satisfactory physical evidence of this type of construction has already been produced, and tests being conducted will tell how well adapted this type of construction is under field conditions for production, accessibility, and maintenance. Their motor mountings are complicated, although they are very robust. They build the engine in, frame fashion, and employ a great number of rivets.

One of their latest models is a three-motored bombardment or passenger-carrying plane, which is their best interpretation of the French three-motored, long-distance, night bombardment specifications. It is designed, as hereafter mentioned, under the specifications requiring a central fuselage with twin wing motor installation. I believe that tubing is far more economical from a structural standpoint than this type of construction.

The Wibault Co. has developed a radical interpretation of a single-motored, night bombardment ship absolutely different from any of the existing French prototypes. This machine has been conceived with the fundamental idea of preserving the most efficient aerodynamic outline possible. The machine is all-metal construction and has the entire load of accessories, bombs, and fuel disposed within the structure proper. This machine has recently made its first test flights and should be observed closely with a view to ascertaining the advantage of this type for the fulfillment of its night bombardment mission.

The metal construction has been very thoughtfully carried out and, although it does not represent the utmost in simplicity to be desired, it is the most representative type of up-to-date all-duralumin construction in a French military machine. This machine has been very thoughtfully designed to meet the specifications that have been laid down by the French air service. The absence in the major part of their metal construction of a lot of flimsy sheet duralumin pieces, and the utilization of tubular construction wherever it has been possible, are the outstanding features of the Wibault machines. This machine should be very closely studied to determine whether or not it would be desirable for us to do experimental work along the same general lines.

The Wibault Co. is also constructing a single-seater. supercharged pursuit plane of the "parasol monoplane" type, motored with the Hispano-Suiza, which should be very closely observed in its development. If it has the desired maneuverability, it will represent a type suitable for pursuit work at altitudes.

Mr. Wibault employs fabric for all his surface and fuselage covering. The advantage is the ease of inspection of the internal-construction units, accessibility, and ease of replacement. Deterioration in the field when exposed to the weather is going to make the covering relatively short lived, but this deterioration requires only the replacement of fabric and not of any major structural part. This is a point to be very seriously considered in our own program when studying the design and construction of our future all-metal wings. In considering whether or not we will adopt metal wings with fabric covering or metal wings with metallic covering, it should be remembered that the advantages or disadvantages in either case are not alone concerned with the covering.

The Morane Saulnier Co. has designed and built during the past year an internally braced monoplane with tapered wings, powered with three 370-horsepower Loraine engines or three 400-horsepower Liberty engines. One of the engines is located in the nose of the fuselage and the other two engines are located immediately to either side and in the leading edge of the monoplane wing. The structure of the machine is entirely of metal elements, although the wings and fuselage are covered with fabric. The wing spars are duralumin trellis-type girders. The landing gear is of the two-wheel type with two vees extending from the bottom of the fuselage out to the wheels and with the compression truss extending up from the wheel shock-absorber point to the underside of the wing engine mounts. The wing is divided practically into three distinct plan sections, the center section being of a uniform chord and depth, while the outer sections from the engine location taper toward the wing tips, both in chord and depth. The control surfaces are all balanced. The engines are so disposed as to prevent the blanketing of the respective propeller-disk areas. The fuel tanks are situated in the wing just over the outboard engines and no fuel is carried in the fuselage. Fuel capacity is sufficient for seven hours' flight with full load. Provision is made, however, for the immediate emptying of the fuel tanks, should the necessity arise in flight.

The fuselage is of rectangular section and has nose radiator mounted for the fuselage engine. Control compartment is fitted with two seats ahead of the wing, affording excellent visibility.

A tunnel leading from the control cockpit to both wing engines enables the mechanic to make motor adjustments in flight, and the central engine, of course, may be directly reached from the control cockpit proper.

This machine has recently been completed and is now ready to undergo tests. It has been designed, however, as a passenger carrier and provisions are made for the location of 16 passengers. However, this machine is readily adapted for conversion into a bombardment type, and if the experiments prove out well on this first machine it will be converted into a military type. It represents a very novel type and has really been influenced in design by the advent of the large Zeppelin Staaken type. Being a three-motored job, it will blend in well with the requirements of the French bombardment type specification requiring three motors. Flight tests will be conducted very soon at Villacoublay, and the results should be watched very closely.

FRENCH PROGRAM FOR NEW AIRPLANES.

EXPLANATORY NOTE.

The French have laid down a definite program for their new airplanes which contains a discussion of requirements with suggestions for their installation. This program for new airplanes has been translated from the French using as free a translation as possible in order to make the information understandable even to a layman. In several instances, however, it was impossible to give a free translation and maintain the exact meaning of the French. In other cases there was some question as to exactly what was meant and in both of these instances a literal translation has been given.

Table of French aircraft.

Type.	Existing or experimental.	On order.
Pursuit, low altitude	Nieuport 29 C-1. Hanriot. Spad.	Nieuport. Spad.
Pursuit, high altitude, supercharged	Nieuport.	Spad. Wibault. Nieuport.
Pursuit and reconnaissance, 2-place, observation.	Breguet. Spad. Farman. Hanriot. Salmson. Potez.	Hanriot. Gourdou. Spad.
Day bombardment	Breguet. Farman.	Potez.
Night bombardment	Breguet. Farman.	Morane. Wibault. Potez. Latecuere
Ship planes	Nieuport. Hanriot.	Spad.
Torpedo planes		Farman.
Training	Hanriot. Morane. Caudron.	Spad.

I. GENERAL QUALITIES REQUIRED.

Power.—The basic French plan to improve the flying performance of their aircraft is to make the most efficient use of power rather than in increasing it.

Of two airplanes which bear the same load with the same speed at the same altitude, the one using least horsepower is much the better, since it permits of greater maneuverability, is easier to land, and has a smaller consumption of heavy, costly fuel.

Number and types of motors to use.—Light, fast, maneuverable airplanes would necessarily have a single motor.

Efficiency.—Special attention of the constructors is called to the increase in the efficiency of airplanes which can be obtained by careful study of the lifting quality of the wings, of the parasite resistance of the accessory parts, and of the efficiency of the propeller.

The lifting quality depends upon the choice of the profile and upon the resistance of the wings.

Actual experience has shown that from a lift viewpoint the best biplane wings are those which have the lower plane narrower and which have forward stagger.

Head resistance of the airplane should be studied for each part, and the shape of the fuselage will be such that it will hold all the accessories.

The question of water and oil radiators will be particularly investigated, as will also the air outlets of the fuselage, which actually occasion very great resistance by the whirls which they cause.

In general, the head resistance of an airplane of a series of separate parts is greater than the sum of the resistances of the parts considered alone, and much greater than the resistance of the parts grouped in a single body even though the individual resistance is large.

The efficiency of the propeller will be augmented by the choice of its profile. The narrow propeller of great diameter has been shown to be the best simultaneously by the experiments of the laboratory and direct measures of the performances on the airplanes.

In all cases, when possible, the propeller should turn at a low number of revolutions. Gear reduction is interesting if it functions well, even for fast airplanes.

With the present motors, a reduction of one-half could be considered as desirable on all airplanes.

Such a reduction augments by 9 per cent the efficiency of the propeller if it is alone on its shaft: $P_1 = P_0 \times 1.09$; and by 12 per cent if it is tandem with another propeller: $P_1 = 1.12\ P_0$.

This augmentation of efficiency also holds true for the greatest speeds actually practiced.

High-altitude airplane.—For high altitudes the determining element is the weight of the motopropeller group brought from the useful power to the maximum height attained by the airplane.

High-altitude airplanes present two totally different problems.

The first solution involves the use of very light motors, air-cooled if possible, calculated for functioning in cold air at high altitudes and provides with a checked feed for low altitudes, so that the pressure and the temperature borne by the parts might not be excessive.

The second problem permits the use of motors calculated for functioning at sea level. This is accomplished by feeding gas to the carburetor at a pressure practically constant This solution involves a turbocompressor.

Airplanes for medium altitudes.—The airplane for medium altitude must be easy to fly and must have a motor without complicated accessories. One designed for regular functioning of many hundred hours will be the best.

Heavy airplanes.—Heavy airplanes will certainly have to be either three or four motored to be dependable. These motors will be chosen primarily from the standpoint of reliability. Their installation and accessories shall be completely independent so that the failure of one motor or any of its accessories will not produce the failure of several motors such as might be the case if they had accessories in common.

The bimotored plane is the most dangerous to handle in case of failure of one motor, is the least regular in operation, and should not be further considered.

Stability.—Airplanes ought to be inherently stable, climbing gradually if the motor is accelerated or gilding normally if it is throttled.

When the motors are cut out the airplane should automatically start to glide at an angle which is slightly greater than the normal gliding angle of the machine.

In a turn, with motor full speed or cut out, under the action alone of the rudder, the airplane should tilt naturally to make the drift negligible.

Compensation of multimotored planes.—In the multimotored airplanes a contrivance will be provided to permit counteracting the unbalancing effect from the stopping or the loss of power of any of the motors without subjecting the pilot to additional fatigue. An example of this is a compensator on the rudder bar to prevent the plane turning to the right or left.

Longitudinal equilibrium.—An airplane with a full load should be balanced longitudinally for ordinary flight conditions with the motor turning at its normal revolutions. Of course this means at the altitude for which it was designed. It must not be tail heavy or nose heavy.

Maneuverability.—Response to controls should be very easy so that the airplane will not be fatiguing to the pilot. The effort required by the pilot should always be proportionate to the effect desired.

This result is easily obtained by using as ailerons, elevators, or rudders, mobile surfaces relatively long and narrow, partially balanced and combined with carefully considered fixed surfaces placed before the movable surfaces.

In all cases the three controls should be designed to require a similar amount of muscular effort in the different evolutions of the airplane.

An airplane control which can easily be thrown out of gear should be provided for use of one of the observers in multiplace machines.

Comfort.—The crew should be arranged in such fashion as to avoid all unnecessary fatigue during a flight. Seats with upholstered backs should protect them from vibrations. They should be protected from the oil spray and the wind by windshields, or better yet, the profile of the plane should be such that the air flow does not strike them yet permits them to see without interposition of

glass or any other transparent substance. They should be protected from escaping gas.

Visibility.—The field of visibility of the pilot and observer will be one of the most important considerations in the design of any airplane. Details regarding visibility for different types of planes are given elsewhere.

Location of the observer.—In the multiplace machines, one of the observers, at least, should be placed very near the pilot, close enough to be able to communicate with him by voice without the aid of any acoustic apparatus. Each position should permit the use of a parachute. The pilot in any war machine must not be placed as in the Salmson.

Durability of airplanes.—All airplanes to be constructed should be capable of several hundred hours of efficient flying with absolute safety.

They should be capable of being stored indefinitely without deterioration.

They should be capable of being kept out in the weather without serious harm.

This demands that the wing construction, including ribs, be entirely of metal.

Paints, varnishes, or protective dopes should be used which would protect the thin sheet metal against climatic conditions.

Ease of assembly and maintenance.—Assembly should be simple and easy and covered by brief, clear directions. This requires that the parts be clearly marked and that the instructions cover the system of marking. The maintenance should be very easy and should not necessitate the employment of specialized personnel.

Interchangeability.—The manufacturers of airplanes should be directed toward the realization in the near future of perfect interchangeability of the parts. This is of great importance where the replacement of unserviceable parts must be made as rapidly as possible without skilled mechanics.

Equipment and armament.—All the airplanes should be submitted with their complete equipment and must make their trial flights carrying full equipment and armament prescribed for this type.

II. STRUCTURE STATIC RESISTANCE.

Wings.—As a general principle, the static tests under the control of the technical section should be made before the first machine leaves the factory.

For the load applied underneath the wings, the coefficients of safety to adopt should be the following:

$$\text{Pursuit and combat planes} \ldots\ldots 10 \ \frac{S(Vo)^3}{To(100)}$$

$$\text{Other airplanes} \ldots\ldots\ldots\ldots\ldots 7.5 \ \frac{S(Vo)^3}{To(100)}$$

In this formula S is the surface in square meters of the wings. To is the horsepower at sea level and Vo the speed in kilometers per hour at sea level.

These coefficients should be multiplied by 1.5 for mono planes.

If any one of the wires or any one of the attaching metal fittings of the wing should be taken away (or shot off), the wing should resist statically with a coefficient of one half less. This disposition is applicable to internal drift and wire fittings in the interior of the wings.

The wing should be submitted to dissymmetric static tests.

Fuselages and empennages.—The empennages should be built to support in the static tests a load of sand equal by m² to three-fifths of the maximum by m² supported by the wing in the static trial underneath.

The fuselages, loaded with weights double those which they must carry normally, ought besides to support the empennages loaded as stated above.

To verify their resistance to torsion, they should be submitted to dissymmetric test.

Landing gear, axle, and tail skid.—The stress which the landing gear, the axles, and the tail skids should bear before breaking should be at least equal to five times the static load with the airplane resting upon a horizontal surface.

These stresses must also have a horizontal component equal to half of the vertical component.

Elastic cords should be established so that the maximum strain may not be surpassed, the machine falling vertically from $0^m 50$ if it is used on a day airplane; from 1^m if it is used on a night airplane; and the adjustment should be such that the elastic bands enter into play effectively, since the stress should not surpass that which they should bear at rest.

The tests should be furnished with a checking arrangement so that, in any case, the fixed parts of the airplane can not touch the ground.

The tail skid should be placed in such a manner that, after the maximum expansion of its elastic bands, the rudder and the stabilizer should not graze the earth in bad fields.

III. DETAILS OF CONSTRUCTION OF THE AIRPLANES.

Assembly.—Disassembly, reassembly, and transportation ought to be easy. The wings, particularly, should be able to be taken apart into pieces of not more than 8 meters in length, which can be easily transported by railroad.

Standardization.—For the parts for which the technical section will have specified standard tables, the dimensions figuring in the tables are exclusively specified. Standard tables are established particularly for the:

Steel.	Bolts.
Canvas and bands.	Turnbuckles.
Cables.	Tubes, round and stream line.
Piano wire.	Screw threads.
Tapering wire.	Cocks, valves, and brass work.
Thimbles.	Wheels.
Wire ferrules.	Propeller hubs.

Replacement.—It is necessary that all the parts which deteriorate ordinarily more often than the wings be easy to replace. These parts are the landing gear, tail skid, motors, radiator, tanks, etc.

It is indispensable that there be interchangeability of all assemblies or detachable parts capable of being replaced in organizations at the front. These different parts ought besides, to be marked in such fashion as to obviate errors in setting up (high, low, right, left, forward, rear, etc.).

Complete production drawings should be furnished to permit the rapid manufacture of spare parts, if necessary, and to insure absolute interchangeability.

Maintenance.—All the parts submitted to strain should be capable of inspection and easy replacement. It is

particularly so in the case of the crosspieces of the fuselage, of the tail-skid supports, of all control cables, guides, or pulleys over which they pass to the interior of the wings or from the fuselage, and of all the levers, aileron controls, etc., transmitting the movement from the control parts to the ailerons, elevators, and rudders.

Mud guard.—The wheels ought to be supplied with removable mud guards to obviate the throwing of mud or gravel into the propellers.

Steps.—Steps should permit the aviators to mount into the machine without risk of injury to the wing or any accessory. These steps should not permit the entry of air into the fuselage.

Seat.—The seat of the pilot should be adjustable in height.

Rudder bars.—The rudder bars are adjustable from one of the unified types adopted by the technical section.

Floor.—The floor should be furnished with an arrangement permitting the pilot to see the terrain under him; for example, controlled shutters and floor guard with openwork.

Controls.—All the control cables should be double, with separate points of attachment.

Wind shield.—All airplanes should be furnished with a windbreak or windshield for each person.

IV. SETTING UP OF THE MOTOR AND ITS ACCESSORIES.

A. General.

Management and function.—Every motor ought to be mounted so that its management may be easy.

It ought to be able to function without difficulty in any position of flight in which the airplane is likely to be placed. For pursuit airplanes, this means a zoom of 200 meters, dive of 1,000 meters, or glide under an angle of 30°. For multi-motored ships the feed ought to be assured for any turn effected with the minimum radius of gyration.

Every motor ought to pick up readily after a descent of 2,000 meters with the engine throttled.

Assembly and disassembly.—The motor should be constructed as directed by the State and no modifications destined to diminish the interchangeability on the airplane should be allowed without the consent of the technical section.

The replacement of a motor or of a group motor in an airplane, or of an important accessory, such as the radiator, tank, etc., must be able to be effected in less than eight hours, with two mechanics and with the ordinary facilities available in a light squadron workshop.

The disassembly of important parts, such as radiator, tank, carburetor, magneto, or pump, ought to be effected in less than three hours, without necessitating the complete removal of the motor.

Provisions should be made for the installation of such a type of connections and controls that the power plant may be removed from the airplane without difficulty in the minimum time.

Changing the motor ought not to necessitate the disassembly of any of the accessories—pumps, carburetors, or magnetos—which might be put out of order.

The cowling should be strong enough to withstand at least 10 disassemblies. Its replacement ought to be effected in one hour.

An opening should be provided for inspection large enough to permit access to the parts of the motor which need periodic surveillance: pumps, pressure gauge or regulator of the rate of flow, sights, filters, drain cocks, stopcocks, magnetos, distributors, contact breakers, carburetors, jet, constant level, and spark plugs.

The cowling, in spite of its removability, ought to be water-tight, and ought to potect the aviators, windshields, and sights from all oil or water spray.

Carburetors.—The carburetor mount should be designed to receive any of the different models of carburetors adapted to a same type of motor.

Precautions to obviate danger of fire are treated under the next main heading.

The carburetor and its frame should be heated and adjustment should be provided to permit an economical functioning for temperatures of 40° to 30° for all altitudes and at all speeds. The air admitted ought to be warmed.

Hours of flight.—The capacity of the tank or tanks for gas ought to correspond to the number of hours fixed for the running at sea level of the motors at full throttle. The capacity of the oil tank corresponds to the duration of the flight at full speed and at the specified altitude possible with this supply of gas, augmented by the minimum reserve for assuring circulation and a margin of safety of 20 per cent. The specific consumption of the motors increases with use.

The attached chart contains the basic elements of calculations for the tanks of gas and oil with the present motors and will be revised as new motors are designed.

Table of consumptions of oil and gas of aviation motors.

Motor.	Type.	Horse-power.	Maximum pewor T.	Power full limited admission at sea level T_1.	Specific consumption per horse-power hour in kilograms A.	Hourly consumption in kilograms ($T_1 \times A$).	Oil hourly consumption in kilograms.	Oil reserve in circulation.
STATIONARY MOTORS.								
Bugatti	16 C	450	460	420	0.250	105	8	4
De Dion-Bouton	16 A	800	900	800	.260	210	30	6
Hispano-Suiza	8 F	300	320	280	.245	70	6.5	4
Hispano Cannon	12 C	450	450	420	.250	105	8	4
Liberty	12 L	400	410	370	.240	92	6	4
Lorraine-Dietrich	8 B	275	275	240	.250	60	4	3
Do	12 Da	370	390	300	.250	75	8	4
Do	12 Ch	500	500	....	.250	125	10	....
Panhard-Levassor	12 O	340	340	320	.230	75	75	4
Do	12 E	500	520	480	.230	110	18	5
Do	12 Ez	500	550	480	.230	110	18	5
Do	16 F	600	690	640	.240	155	23	6
Renault	12 F	300	330	280	.250	70	6.5	4
Do	12 Kb	450	460	380	.260	95	11	5
Do	12 M	600	590	540	.260	140	15	5
Salmson	9 Z	230	260	230	.245	57	8	4
Do	18 Z	500	560	460	.235	110	20	6
ROTARY MOTORS.								
Clerget	9 B	130	135	125	.285	34	8.5	2
Do	11 Eb	200	200	180	.380	68	11	3
Rhone	9 Z	120	130	120	.285	33	6	2
Do	9 R	170	170	150	.280	42	7.5	2

Gas and gravity tanks.—The feed of each motor must constitute an independent assembly for gravity, pump, and service tank, and in addition any tank must be able to feed any motor.

Each tank should be able to be filled easily and quickly with an ordinary funnel and should be furnished with levels or gauges visible to the pilot. If the breakage of these levels risks involving the flow of the gas, a cock within easy reach of the pilot should permit cutting it out of the system.

Gravity tanks, with load of gas, should be provided at the rate of one for each motor. These gravity tanks are designed for continuing the flight for 50 kilometers in case of accidental emptying of the service tanks. They feed the motors directly and are protected.

Changing from service to gravity tank should be done automatically or at the will of the pilot.

Feed at full throttle should be assured automatically while there remains even 1½ gallons of fuel in any one of the principal tanks.

The leakage in a tank should not be able to involve the emptying of the other tanks.

Cocks optionally managed by the pilot should permit the isolating at will of any number of these tanks.

The pilot should be able to withdraw the gas in the full tanks at will, either by an automatic arrangement of pump or exhauster or by a hand pump made in such a fashion as to utilize all of the gas.

The use of tanks under pressure is forbidden.

The permanent refilling of the gravity tanks should be assured at will by the normal system of feed and by aiding with hand pumps. The flow, in the second case, should be sufficient to assure the normal functioning of the motors.

The automatic valves are completed by safety cocks. A cock, manageable by the pilot, should permit the cutting out of any one of the tanks, the carburetor, or the pump.

The supply tanks are furnished with an overflow pipe with circulation sight and of a diameter double that of the intake; the opening to the atmosphere should be made in a zone with a current of air.

Each pump should be able to feed any one of the motors and to have a maximum flow sufficient for the consumption of two motors.

The tanks are established in conformance to the specifications governing them.

Lubrication.—The lubrication of the motors should be done automatically, not demanding the attention or action of the pilot in the course of flight.

A control arrangement of the lubrication (manometer, sight, etc.) should be installed with a cock permitting isolation in case of breakage.

It would be advantageous to connect to the motor a system of direct injection of warm oil in the tubes which supply the bearings before starting the motor.

The valve limiting the oil pressure, and the oil filter should be accessible and easily disassembled.

The tube connections should be strong enough to permit effective clamping and provided with a control designed to prevent their coming open. Measures should be taken to prevent the deterioration of the hose connections by the extreme sharp edges of the metallic tubes. The ligatures should be made with rings.

The outlet tube of oil from the tanks should be surrounded with a strainer at least a centimeter high.

The oil should be maintained during flight at a temperature lower than 70° and higher than +10° for mineral oil and +5° for castor oil, whatever may be the outside temperature. This is to be done by means of radiators and nonconductors.

All the tanks should be surrounded by cork and the outside tubes should be insulated.

The blow valves of the motors and tanks should be arranged to obviate loss of oil by throwing oil vapors on the pilot.

All the tanks should be, as nearly as possible, in load on the pumps in order to utilize gravity to the maximum and to reduce the chances of unpriming the pumps.

Cooling.—The water-cooled motors should be furnished with a thermometer indicating the temperature of the water at the intake to the radiator (for airplane type a thermometer should be allowed for at the outlet of the radiator.)

The radiators should be placed as well as possible for protection from vibrations and should be supported completely, either by the motor or by the fuselage, and reinforced at the points of support. Water-tightness should be assured even if there should be a local tearing of the fixation rivets.

The different fittings should be reinforced by small rings. The water admission should be designed for using the flow with the minimum of resistance. The flow of the radiator in the weakest section and under a load of 0^m 40 of water should be at least equal to that of the water pump of the motor under the same governing load over the cylinder heads.

They should carry an emptying arrangement permitting complete evacuation of water, or refilling through the bottom. The stopper for this arrangement should be of standard dimensions. At the intake a fine filter should be installed to stop the impurities. This must be accessible. At their outlet a fixed filter with large mesh for stopping the grains of solder should be provided.

The radiators for any type should be established on a model in such a fashion as to be interchangeable in an airplane.

The highest point of the water circulation should be at least 0^m 60 above the most elevated point of the motor high point water system and should be furnished with an emptying stopper of a standard type. The high local points for the different positions of the airplane should be provided with tubes connecting them to the higher level. In any case, the water reserve should be placed above the higher level of the motor water system high point for a 20° angle of ascent or descent.

The cooling surfaces of the radiators should be calculated in such fashion as to assure a maximum difference of temperature of 65° between the surrounding atmosphere and that of the water at the outlet of the cylinders, at sea level, in the regions of France. This difference is to be reduced according to the latitudes for colonial airplanes.

A simple, strong apparatus should permit the regulation of the temperature of the water during flight. Its controls should be double and, in case of breakage, should automatically return to the position of the maximum cooling.

The radiators should be protected from earth thrown up by the propeller.

Cocks and levers.—All the cocks and levers which must be managed in flight should be in easy reach of the hand. Duplicated cocks and levers should permit the secondary pilot to manage the motor in case of necessity. Their dimensions and their position should permit of comfortable and effective management, even by hands covered with big gloves and in spite of a resistance of about 40 kilograms.

Control cocks with needle valves should be completed by cocks of one-quarter revolution, permitting rapid closing. They should be water-tight. Some safety devices should prevent the displacement of these cocks and levers under the influence of vibration.

The cocks and levers should all be furnished with legible indicating dials. The lever controls of the carburetor should bear a special notch necessitating a movement for being freed and provided with a stop corresponding to full limited throttle admissible at sea level. The altitude at which total admission is admissible should be printed upon the instrument board. The carburetor controls should, so far as is possible, be synchronized so their successive positions indicate the progressiveness of the number of revolutions of the motor.

Ignition.—The wires should be well insulated and terminated by unhookable clasps. No metallic parts should be found less than 1 centimeter from the ends of the longest spark plugs used.

A separate switch should permit the stopping of each motor, and a master switch should permit the stopping of the whole group of motors.

Manifolds.—The manifolds should be as short as possible, with streamlined shapes, constructed with the minimum number of elbows, and arranged with supports and flexible connections to obviate breakages under the influence of vibrations. They ought to be easily accessible throughout their whole length.

Account should be taken of the load and the resistances in the dimensions of the pipes, which should permit a load higher by 50 per cent at least than the necessary maximum under the most unfavorable circumstances.

Manifolds for gas, oil, and water should be immediately recognizable by their color. Special connections should facilitate this division from the motor to reduce to the minimum the number of flexible connections in sections.

Flexible connections should remain in good condition for at least two years.

Apparatus for the emptying of the tubing should be closed up, not by stoppers, but by special cocks.

Silencer.—The silencers must be easily removable. They should be as effective as possible, particularly for bombardment planes. The pilot and bomber should be able to hear each other. They should conceal the glow and be invisible at night. They should be able to resist vibration and expansion proceeding from heating. Their cleaning should be simple. The total absorbed power consumed by their weight, loss through checking of the gas, and the head resistance ought to be lower than 5 per cent of the total power of the motor in fast airplanes and 8 per cent in bombardment planes.

The exhaust gases should be discharged at a distance from the aviators, in order not to interfere with firing or observation, and must consider the direction of the suction of air by the propeller and of the slipstream eddies. This disposition at the side of the fuselage presents some advantages from this point of view.

Starting device.—All the motors should be supplied with a starting device on the dashboard, not requiring the whirling of the propeller by hand and assuring departure in less than five minutes regardless of temperature.

All the hubs, in addition, should be furnished with a propeller-hub clutch on the front of the propeller, permiting starting of the airplane motor with an airdrome mechanical starter.

Accessory controls.—Tachometer, manometer, and connections should be of standard type. Gasoline-pump controls should be standardized for each of the types. Flexible controls are allowed only on condition that they have no elbows.

Engine supports.—The motor bed and the wing fittings should be able to resist the maximum couple of the motor. with a coefficient of safety of at least 7, in order to take account of vibrations.

B. *Measures of precaution to take against fire.*

Causes of fire on an airplane proceed:

1. From the functioning of the motor and its accessories, and from accidents in landing.

2. From conditions of special present use in war (hits from projectiles, incendiary or otherwise).

3. From installation of special apparatus (compressed gas, different electric installations, etc.).

Only the two first groups will be considered in this note The appliances and special apparatus whose installation might be a cause of fire ought each to be studied from this point of view. It is impossible to establish precise rules of priority.

1. Causes of fire proceeding from the motor and its accessories.

The danger of fire proceeding from the motor can be caused by:

a. Gas from the exhaust.
b. Disposition of electric ignition.
c. Backfiring in the carburetor.
d. Excessive accidental leaks in certain parts of the motor.

In order that fire might spread it must meet a combustible substance—wood, canvas, oil, gasoline, or gasoline vapor.

For this reason no deposits of gas or oil should be allowed even momentarily. They should be disposed of immediately by effective ventilation. Possibility of leakage of gas and oil ought to be reduced to the minimum.

a. Exhaust gas: Particular precaution must be taken at the joints of all flanges to prevent the entry of exhaust gas into the interior of the cockpit.

The parts of the airplane near the exhaust, and the cockpit in particular, should either be metallic or protected by fireproof covering (asbestos in sheets or in strands). An air current of at least 2 centimeters is a good insulator.

Exhaust gases ought to be well away from the gasoline manifolds, tanks, pumps, carburetors, and entirely apart from closed spaces where gasoline vapors might accumulate.

In case the exhaust gas is used to warm the carburetor, the manifolds of warm gas ought to be perfectly tight, carefully installed, and the gases discharged far back from the carburetor intake.

b. Ignition apparatus: The high-tension magnetos and their leads are to be inspected very carefully.

Sparks which can flash between the high-tension leads or their adjacent metallic parts and the points where the circuits present a continuous discharge are likely to ignite the gasoline vapors. This, then, is the place to use sure insulations and strong connections provided with safety attachments.

Insulations generally used for the covering of high-tension leads are easily destroyed by the action of heat. If placed near a very hot motor wall, they can melt and short-circuit, frequently causing fires.

The leads ought in no case to pass under the gas pipes.

c. Backfiring: Backfiring is caused by bad functioning of the motor, carburetor, or, more rarely, the ignition. The latter is indeed rare, but can not be completely avoided.

Knowing the gravity of the consequences, the adaptation of the motor to the airplane ought to permit all backfiring without the least danger of fire.

Realizing that the most improved motors still have danger of fire, it is essential to stop or to limit the spreading of the flames in such a manner that they may not reach an inclosure of gas or find inflammable bodies.

For this the following principles should be applied:

(*a*) Either (1) lowering the temperature of gas by wire gauze, or (2) mechanical isolation by automatic valves.

(*b*) Complete evacuation to the exterior of the fuselage of the dangerous flames which the preceding contrivances would have allowed to escape.

For greater security the drawing of air from the motors, which serves at the same time for evacuation of the gases from the return and for the drawing in of fresh air in normal functioning, should bear no communication with the interior of the cockpit. This last disposition is to bear on all installations. Upon the passage of these gases the necessary heating can be arranged.

Wire gauze can be replaced by other coolers, such as the Lelarge device, which operates by subdividing the ignited mixture and the caloric "drainage" by means of aluminum spheres in a box which remains permeable to air.

Evacuation of gas in excess.—When starting the motor and during certain maneuvers in the air, especially in a dive, there is often considerable entry of gas into the air-intake pipe.

It is essential to provide drain nozzles to the exterior, connected to each of the low points of the intake manifold at "relatively" low points, to be determined for the different positions of the airplane (normal flight, climb, glide, or dive). If the carburetor is not leak proof. an overflow outlet tube should be provided at the constant level.

Carburetor and feed.—Carburetors ought to be as air-tight as possible, and the heating of the gases and their speed in the manifolds sufficient for any altitude. Feed ought to be assured in all positions and under all conditions of flight. Feed under pressure should be prohibited because it is too delicate, too sensitive to variations of altitude, and to the amount of gas in the tanks.

Cut-out.—The cut-out should be very accessible and of sure functioning to assure stopping the motors in case of accident in landing.

Tank.—To avoid danger of fire in certain cases of bad landings, the dropable tank mentioned hereafter is interesting.

2. Proper special protection to an airplane in case of war.

There are special dangers of fire to an airplane in case of war proceeding from hits by enemy projectiles. Ordinary projectiles can injure the feed lines and cause leakage of the gas where it is likely to come into contact with the hot parts of the motor. Failure of gas to the carburetor produces back-firing, which is fed immediately by fuel leakage. Incendiary projectiles introduce new and dangerous direct causes of fire.

Every effort should be made to reduce to he minimum the dangerous area and to develop the manifolds. Protection of the fuel tanks is obtained by the following means:

a. A special complete exterior envelope of layers of rubber and Lanser-Dunlop trelliswork, which is nonleakable in spite of perforations. In order for this covering to be effective, the sheet iron making up the tanks should be thin and ought not to be under pressure (another reason for prohibiting pressure feed).

b. Rapid action release cock (30 seconds at the maximum).

c. Dropable tanks designed specially to function in spite of any deformations due to its penetration by a projectile.

For the small reserve tanks protection is obtained by the coverings stated above, by armor plate, or by a double metallic envelope with an inside layer of a special material of the Daigre make.

Propellers.—Propellers ought to be designed for airplanes and motors in such manner as to furnish at the altitude of use and in horizontal flight the maximum power compatible with the operation of the motors at this altitude. The efficiency under these conditions ought to be at least 75 per cent and ought not to fall below 60 per cent for any of the other conditions of flight. With wooden propellers the maximum permissible linear speed at the tip of the blades is 270 meters per second.

As a general rule the coefficient of safety corresponding to the rate of strain of the material ought not to fall below 4 for army corps, reconnaissance, and bombardment airplanes; and not below 3 for pursuit airplanes.

The propellers should be perfectly balanced.

The airplane being placed on the ground, in line of flight, the minmum distance between the earth and the lowest point of the circle swept by the propeller ought to be equal to 0^m 25 (d) and, in all cases, higher than 0^m 45. (d) representing the distance between the lowest point of the circle swept by the propeller and the point of contact of the wheels on the ground before the landing gear.

Rear propellers should be protected against earth being thrown against them by mud guards placed on the landing-gear wheels or by some other device.

The propeller hubs of the standard type should be supplied with standard propeller-hub clutch with a view to being started by the mechanical starter. An entire new system of hub motion should be studied by the technical section before adoption.

The manner of attaching the propellers to the shafts ought to be such that assembly and disassembly of the propeller may be effected on the airdrome in less than an hour.

V. ARRANGEMENT OF THE COCKPIT INSTRUMENTS AND INDICATING APPARATUS.

Cockpit instruments are necessarily of regulation types and should be installed in a uniform manner determined by the technical section.

The tachometer, altimeter, watch, and speedometer particularly should be placed on the instrument board according to a well-established arrangement. Provision should also be made to receive, in addition, the different manometers, thermometers, levels, etc., used on an airplane.

The instruments on the board, and the compass also, ought to be entirely visible to the pilot.

They should be easily seen also by the relief pilot. If this can not be done, he should be given an altimeter, a watch, and a compass.

Installation of map cases of the regulation type should be provided for each aviator. The map case should be able to turn in its plane, which should be perpendicular to the line of vision of the aviators.

VI. ARRANGEMENT OF THE ARMAMENT.

A. Firing through the propeller.

1. Vickers guns should be set up in such a manner as to permit access, with thick gloves, to all the control levers and to the different parts of the synchronizers. The top plane of the machine guns should be at the height of the shoulder. Their installation should be from 30 to 40 centimeters and the wind shield should be placed in such a manner as not to hinder access, among other things, to the loading handle on the left-hand machine gun.

2. The sights used should be either a telescopic sight or a ring-and-bead sight. A natural line of vision should permit direct aim. The aiming field of these devices should be free from all obstacles. They should be fixed to a rigid part of the airplane in such fashion that vibrations should not bring about any disorder. Aiming ought not to necessitate more than slight movements of the head of the pilot.

3. Disassembly of the machine guns ought to be made in 10 minutes.

The forward and rear axes of fixation ought to be quite accessible. Alignment of the machine guns ought to be done by adjusting parts situated in the rear.

4. A tangent brought from the eye of the pilot to the cowl of the airplane, in the transversal plane of the pilot, ought to make 35° to 40° with the horizontal.

5. Links should be received for at least one machine gun. Cartridge cases should be ejected outside the machine.

6. Cartridge boxes should have a surface minimum of 1,500 square centimeters per machine gun. They should be moveable and their loading extremely easy.

7. Finally, the cowl should be quickly removed and should not be fixed to the rest of the airplane except by swivels or shafts which can be instantaneously removed. The use of bolts should be absolutely forbidden.

B. Machine-gun tourelles.

1. Installation of machine-gun tourelles upon reconnaissance and two-seater fighter airplanes:

The type of tourelle to be mounted upon the airplane should be determined by the technical section. Placing of it upon the airplane should be studied before approval.

The field of fire should be as great as possible. It should be at least an angle of 80° upward and the dead angle under the fuselage to the rear should be reduced to the minimum.

The tourelles should be placed so as to interfere as little as possible with the communication between the pilot and the observer. At the side of the pilot, it should not be possible to pass the gun in the low position, but for all other sectors the rotation of the tourelle should permit every possible position of the guns.

The diameter of the base ring of the tourelle is 800 millimeters.

The diameter of the axis or yoke bearing the guns is 920 millimeters. Accordingly, a free space of at least 950 millimeters diameter around the transverse ring is necessary for the passage of the supporting shaft of the guns in the low position.

Vertical firing under the airplane will only be possible for a fuselage having less than 920 millimeters width.

Stops or devices should be provided to prevent the guns from firing into the field of the propeller.

Field limiters are provided for the tourelles in the cases where guns could touch the propellers.

The tourelle ring should be perpendicular to the plane of vertical symmetry of the fuselage and parallel to the line of flight.

The fixed circle of the tourelle is mounted on a wooden circle which should never be omitted.

The points of attachment of the tourelle base to the airplane should provide a suitable mounting upon which the wooden ring may rest. The clamping of the screws or bolts must not involve any deformation likely to hinder the rolling of the tourelle in the transverse circles.

The attaching wires or bolts fastening to the fuselage should never engage the metal part of the tourelle. These wires or bolts should hold only the wooden circle and should be placed at points as far as possible from the places of attachment of the wooden ring with the transverse ring.

As the gunner's belt is fastened to the tourelle the mountings of the transverse ring and the airplane should be capable of resisting a tearing-out strain of 400 kilograms.

The distance between the position of the tourelle ring and the floor should be 950 millimeters.

Balanced tourelles.—Owing to the difficulty of maneuvering tourelles on fast airplanes, the latter should be provided with a device intended to neutralize the effect of the wind blast. This supplementary device should be placed in the fuselage when possible and protected by shields.

The airplane designers should be responsible for the mounting and functioning of these compensating devices.

2. Installation of tourelles on bombardment airplanes: On airplanes of the bombardment type, generally having very large fuselages, tourelles of 1 meter in diameter or more are provided.

The distance from the position of the tourelle to the floor of the airplane should be from 850 to 900 millimeters.

The technical section will designate the special conditions of the mountings of these tourelles.

Firing under the fuselage.—For permitting firing under the fuselage, steps should be installed in the rear cockpit on each side of the fuselage.

The supports should be mounted in such a manner that the rear gunner can see below the fuselage and fire the lower guns without leaving the tourelle.

The field of fire should include: In the plane of longitudinal symmetry of the airplane, from the vertical downward as far as the tail skid, and from any part of this plane 25° to left and right.

The cross braces of the fuselage should not interfere with firing or with dismounting or reloading.

A trapdoor which can be opened quickly or some other device should be provided to obviate the entry of air into the fuselage.

A device should be provided to prevent the guns from attaining an angle of fire which would be dangerous for the tail of the machine in the course of combat.

C. Installation of Lewis machine gun supports.

In certain particular cases it may be necessary to construct special supports in the airplane.

Gun mounts which are not of standard type or constructed according to the specifications of the military aeronautical authorities should be carefully studied by the technical section before acceptance.

D. Ammunition boxes for the Lewis machine guns.

There should be provided for each tourelle or machine-gun support the regulation number of ammunition boxes corresponding to the number of rounds required.

The magazine racks should be placed in easy reach of the gunner and arranged so as to permit the easy replenishment of the guns during firing.

The general disposition of the ammunition holders for the Lewis machine guns and their installation in the airplane should in each case be approved by the technical section.

All devices supporting movable guns should be easily and rapidly managed and should be furnished with an equalizing system.

Stops or devices intended to prevent the guns from firing into parts of the airplane which might be hit should be provided.

E. Arrangement of bombardment airplanes.

1. Field of visibility and installation of sights:

General requirements.—The pilot and the bomber should be as near as possible to each other and be able to communicate easily by signals and voice without aviophone.

Field of visibility.—Visibility of the pilot: In normal position the pilot should have a field of minimum visibility from 50° to 60° toward the front from the vertical and a lateral field of 15° to right and left. No currents of air should be permitted to enter through the hole made in the floor and a closing should protect the pilot from the light of searchlights on the ground.

Gradometers and inclinometers, visible at night, parallel to the center line of the airplane and placed according to the longitudinal center line of the visibility opening, should be provided.

Visibility of the bomber.

(a) On the exterior of the cockpit.

(b) In the interior of the cockpit.

In the case of a tractor airplane, the bomber requires a field of 75° toward the front, and in addition, in the case of bimotored airplanes or machines of the pusher type, a field of 10° in the rear.

In the case of a tractor airplane, the opening in the floor should have a field of 70° toward the front, attainable with an adjustable seat. In the case of a multimotored air-

plane or machines of the pusher type, they should have a field of 70° toward the front, 10° toward the rear, and in the transversal plane a field of 30° from any part of the center line of the window seat without putting the bomber in an uncomfortable position.

Sights.—Sighting should be provided for either in the interior or the exterior. The best place is on the exterior of the cockpit, at the right. But, when in this position, aiming will not fulfill the conditions of the exposed fields below, or it will be dangerous (neighborhood of the propeller, interference caused by the lower planes); aiming should be provided in the interior.

Exterior.—The field of the sight should be cleared of all obstacles likely to interfere with aiming (wheels, axles, generators, bomb racks, etc.) in a field from 75° forward and 10° backward.

The bomb-rack controls should be placed in easy reach of the bomber while operating the sights.

Interior.—The sight should be placed in the front part of the cockpit on bimotor airplanes. It will have a field of fire provided for in the preceding paragraph on the bomber's visibility. It will be placed in such manner that it may be used without trouble by the bomber. An articulated device should fold it down when not in use, clearing the position of the bomber. The bomb-rack controls should be in reach of the hand during sighting, preferably at the right. The sighting hole should be capable of being cleared entirely of all transparent substance for aiming at night.

2. From the point of view of bomb racks: All airplanes should be designed in conformance with specifications, using standardized bomb racks determined upon by the technical section.

These bomb racks differ according to the nature of the projectiles carried and can be classed as follows:

1. Bombracks G. P. for bombs of 100 or 200 kilograms. These are carried horizontally under the wings or under the fuselage.
2. Special bombracks for bombs of 500 or 1,000 kilograms, being carried horizontally under the fuselage.
3. Horizontal bombracks, Michelin No. 3, carrying all present projectiles from 10 to 100 kilograms, mounted in the wings.
4. Vertical bombracks for bombs of 50 kilograms, being carried in the interior of the fuselage.
5. Vertical bombracks for bombs of 10 kilograms, being carried like the preceding.
6. Horizontal Michelin bombracks for bomb flares, being carried under the wings (two bombs) or on the vertical sides of the fuselage (one bomb).

Bombracks G. P.—G. P. bombracks for bombs of 100, 200, 500, and 1,000 kilograms are of a standard type. Examples of mounting can be furnished by the technical section upon request.

Horizontal bombracks.—Michelin horizontal bombracks are made in 32 or 40 cells and carry either a number of 10-kilogram bombs corresponding to the number of cells, or one of 50 kilograms in place of every four of 10 kilograms; or one of 100 kilograms in place of every six of the 10-kilogram bombs.

Vertical bombracks.—Bombracks for vertical bombs of 50 kilograms are made for 4, 5, 8, and 10 bombs, grouped upon a single row of 4 or 5 bombs, or upon two braced rows (216 millimeters square, sideways, per bomb).

Vertical bombracks for bombs of 10 kilograms, with equal bulk, carry four times more projectiles. These vertical bombracks are compartmented boxes whose dimensions depend on the number of bombs (216 millimeters square, sideways, per bomb of 50 kilograms or for four bombs of 10 kilograms). They should be supported by a special framework for 50-kilogram bombs and for 10-kilogram bombs.

The bulk of the 50-kilogram vertical bombracks is about 0^{m} 35 on top of the frame and 1^{m} 10 on the bottom of the frame. The bulk of the 10-kilogram vertical bombracks is about 0^{m} 20 on top of the frame and 1^{m} 10 on the bottom of the frame.

They should be easily removed from the lower part of the fuselage.

The minimum space between the spars of the wings of airplanes receiving bombs in the fuselage should be 1^{m} 100 (dimension taken on the interior of the spars).

The release mechanism on the top part of the bombracks should not be joined with the top structure of airplane and should be easily accessible. Lateral inspection doors should be provided in communication with those of the bombracks.

With the airplane resting on its tail skid, the distance from the ground under the spars of the lower wing should be 1^{m} 30 at the minimum in the case where 50-kilogram bombs are to be placed in the interior of the fuselage.

The under part of the lower wings and of the fuselage between the wheels of the landing gear in the bimotored planes should be absolutely free from all cables, tubes, or other encumbrances likely to interfere with the suspension or fall of the bombs.

In the monomotored planes, the lower plane should be free of any obstructions immediately underneath, between the wheels of the landing gear.

Control positions.—Release handles of the bombracks upon the bimotored airplanes should be on the right side of the front cockpit, mounted so that bombs can be released while sighting either in the interior or on the exterior.

Auxiliary controls should be provided near the pilot.

Control of the bombracks is generally done by a bare cable over a pulley or through a copper tube.

Passages.—The passage for going from the front cockpit to the rear and giving access to the bombracks should be 400 millimeters wide at a minimum. The height from the floor of the passage under the top structure should permit the passage of a man without difficulty.

Passage from the bomber's position to the pilot's cockpit.—Cross structures between the pilot's post and the forward post ought to be avoided as much as possible or at least should be high enough so that the passage may be made without difficulty or interference with the pilot.

The technical section will communicate to the constructors of bombardment airplanes the detailed characteristics of the above material and also the detailed conditions of assembly.

VII. ARRANGEMENT OF ELECTRICAL EQUIPMENT.

Generators.—All motors are designed to drive electric generators. The installation of generators should consequently be provided for on all airplanes.

If the operation is made by driving belt, it should be provided with a tightening pulley arrangement permitting the taking up of the elongation of the belt.

The cowling should bear an inspection door for the generator, permitting the changing or regulating of the belt and the changing of the generator.

The speed of the generator should be regulated by a governor. The connection wires should be studied with a view to rapid mounting on an airplane in service and should not be mounted in the shop.

Metal fittings.—Provision must be made for attaching the wires of the various devices requiring electrical energy specified hereafter:

a. Wireless.
b. Heat for the passengers.
c. Warming up the machine guns.
d. Equipment for night flying.

Installation of the wireless.—The wireless should be installed to permit functioning in direct or in indirect excitation by simple management of the commutators.

The antennæ wheel should be placed beside the observer's seat in such fashion that it can be wound up or unwound easily with the right hand. He should be able to do this with ease.

The outlet tube of the antennæ should be placed so that its unwinding may be made in the same manner on all airplanes.

The wheel should be placed outside the observer's place.

The transmitters should be secured by the aid of very solid attaching fittings, assuring perfect rigidity during manipulation.

Commutators and adjusting arrangements for the wireless should be placed in reach of the observer and should be arranged for easy management.

The transformer and a voltage regulator should be placed where it is sheltered from the gas vapors.

The receiving apparatus and the storage batteries should be easily removable. They may occupy the place of the photographic outfit.

Night equipment.—Landing lights should be adjustable fore and aft by means of a rigid control managed by the pilot.

The location of the navigating lights should be such that the lights may be quite visible to the observer and at the same time may determine the exact position of the airplane for neighboring airplanes. The navigation lights should be streamlined.

The storage batteries should be removable to permit recharging the battery on the ground.

VIII. PHOTOGRAPHY ARRANGEMENTS.

Airplanes should permit the use of cameras in the conditions provided for their class.

In addition to the general visibility necessary to the management and defense of the airplane, it is necessary that the pilot in horizontal flight can see, under the most favorable angle, the ground from the vertical to 30° forward. This may be done directly by a window, ground glass, diverging lens, by a periscope, or some other apparatus whose bulk will not interfere with movements.

Moreover, the observer should see all the field which escapes the pilot. This may necessitate leaning over the side.

The placing of the camera should be such that its operation does not require the neglect of the surveillance of the sky.

The photographic machine should be in shelter from oil spray and it should not project beyond the fuselage.

It ought to be sufficiently accessible to allow hand adjustments for loading, change of plates, or any adjusting necessary. It should be possible to do this easily with hands covered with heavy gloves, for the largest magazine used in loading the camera.

The installation should take into account the location of the photographic magazines for replacement purposes for the types which are in service.

IX. MISCELLANEOUS ARRANGEMENTS.

Parachutes.—All airplanes should be arranged for receiving as many parachutes as persons. Ability to use the parachute should be one of the first conditions imposed for the arrangement of the interior. A placing of the pilot analogous to that of the Salmson is not permitted in a war machine.

Oxygen apparatus.—Installation of oxygen apparatus should be provided for in all machines.

Cables.—Each machine should be furnished with a device permitting the machine to be towed by mechanical traction and a device permitting the tying down of the machine in case no hangars are available.

FRENCH TYPE SPECIFICATIONS.

The French aeronautical authorities realized late in 1919 that it was necessary to formulate a definite program for the development of military aircraft. The delay in working up a program was due primarily to the fact that France was so stunned at the end of the World War that it was necessary for her to remain dormant until she could ascertain what her future military problems would be. However, she went to work in a very logical way and determined what kind of planes would be necessary in order to insure proper defense. This resulted in definite conclusions in which type specifications were drawn up. The present French technical program is still based primarily on these specifications.

Study and comparison of the French specifications with our own are not only interesting but should be carefully considered in any revision of our requirements. A table showing the various French types with the requirements for each type follows. In addition, each type is considered in minute detail, giving the general requirements, armament, fuel, equipment, and characteristics.

In these tables where the French refer to the military load, they mean passengers, armament, and equipment. The fuel supply is measured in hours running with the motor turning at full speed under sea-level conditions.

Table of type specifications.

Type.	Military load.	Hours gas.	Ceiling, theoretic.	Ceiling, normal.	Speed, ceiling.	Speed, sea level.	Remarks.
	Kilo-grams.		*Meters.*	*Meters.*	*Kilo-meters per hour.*	*Kilo-meters per hour.*	
Pursuit:							
C.1	220-270	2½-3	9,000	7,000	240	120	Monoplace pursuit for high altitudes.
c.1	220-270	2½-3	6,500	4,000	270	120	Monoplace pursuit for low altitudes.
Pursuit and reconnaissance:							
C.Ap.2	400	4	8,500	7,000	200	110	Biplace pursuit or reconnaissance.
C.An.2	400	4	6,000	3,000	190	90	Biplace pursuit and night reconnaissance.
Observation:							
A.2	450	3	6,000	1,000-3,000	200	90	Biplace, C. A., and divisional.
Ad.2	450	3	6,000	1,000-3,000	200	90	Do.
Ab.2	350	2½	4,500	1,000	180	80	Armored biplace for divisional squadrons.
Bombardment:							
Bp.2	580	7	7,500	5,000	190	90	Biplace, day bombardment, long distance.
BS.2	720	4	5,000	1,000-2,000	200	100	Biplace bombardment or attack.
Bpr.3	520	6	7,500	5,000	210	100	Triplace of protection for the day bombardment.
Bn.2	940	4	4,000	2,000	150	80	Biplace, lightly loaded for day bombing and combat.
Bn.4	2,220	7	4,500	2,000	150	80	Multiplace, heavily loaded, night bombardment, long distance.
Colonial	750	6	4,500	2,000	160	75	

PURSUIT.

Monoplace pursuit for high altitudes—Airplane C. 1 type.

General requirements.—This airplane should be easily managed, very strong, very rapid in maneuvering, and able to dive at great speed.

It is indispensable for the pilot that visibility should be as perfect as possible as a condition of first importance for combat and for formation.

It seems that this can be obtained either by the construction of a parasol type monoplane (Morane or Gourdou fashion), or by stagger of the wings in the biplane cellules.

In all cases it is necessary—

1. That the top plane be at the height of the pilot's eyes.
2. That a line passing through the eye of the pilot and the leading edge of the lower plane should make at least an angle of 15° with the vertical.
3. That the slope at the rear of the lower planes permit the pilot to see straight down.
4. That the section of the fuselage and cowling of the fuselage be studied to reduce the dead angle due to the fuselage and to the motor.
5. That the height of the pilot's seat be regulated and provision be made for the pilot to turn himself easily upon the seat.

The airplane should be furnished with a removable armor plating protecting the pilot from the rear.

The motor should be capable of automatic starting.

Armament.—Two rapid-firing guns, synchronized, or preferably a rapid-firing gun and an automatic cannon, are required. The guns may be, at will, either 7.65 or 1 millimeter caliber; 800 cartridges per gun, 30 projectiles for the cannon.

Fuel.—Tanks for three hours' fuel for the motor turning at full speed at sea level.

To avoid excessive weight, it is suggested and preferred to have gasoline rip panels on the bottom of tank to assure emptying of tank in case of fire rather than leak-proof tanks.

Equipment.—The airplane should have provision to provide warmth for the pilot, for installation of oxygen apparatus, Very pistol, automatic photographic apparatus, parachute, and, eventually, interairplane telephones.

Characteristics.—Ceiling, 9,000 meters. Speed at 7,000 meters, 240 kilometers per hour. Minimum speed at sea level at most favorable angle, with motor throttled, 120 kilometers per hour.

Military load of 220 kilograms in case of two machine guns; 270 kilograms in the case of a cannon and one machine gun.

The weight of the pilot's armor is not included in the useful load as listed, which comprises the pilot, machine guns and cannon, their supports and ammunition, oxygen apparatus, instruments, heating equipment, interairplane telephone, Very pistol, and parachute.

Single-seater fighter for low altitudes—Airplane c. 1.

General requirements.—This airplane should have the same qualities of management, or solidity, as the monoplace C. 1, and it should offer the pilot the same visual field.

The realization of this monoplace for low altitudes has no special interest except that the airplane possesses, at 4,000 meters, a considerable superiority of maneuverability and speed over the monoplace C. 1 (a difference of speed of about 15 kilometers).

Armament.—Same as for airplanes C. 1 type.

Fuel.—Same as for airplanes C. 1 type.

Equipment.—Same as for airplanes C. 1 type, except the oxygen apparatus.

Characteristics.—Ceiling, 6,500 meters. Speed at 4,000 meters, 270 kilometers per hour; minimum speed at sea level, with motor throttled and at most favorable angle, 120 kilometers per hour.

Military load, 220 kilograms in the case of two machine guns or 270 kilograms in the case of a cannon and a machine gun. The weight of the armor is not included in the military load.

PURSUIT AND RECONNAISSANCE.

Biplane pursuit and reconnaissance—Airplanes C. Ap. 2 type.

General requirements.—Designed specially for evolutions at high altitudes (7,000 meters). Visibility should be perfect for the pilot and for the passenger. The observer, normally seated, should see 30° forward and vertically.

Pilot and passenger, at the maximum distance, should be able to communicate by sight and voice without aviophone.

The airplane should be capable of fast maneuvers, easy for average flying.

The motor should be particularly reliable in order to give the pilot the necessary confidence for distance missions.

This airplane can be realized with motors of 500 or more horsepower. These motors can not be counted upon for 1920.

The motor for use, then, will be a motor of lower horsepower, furnished with a device permitting the conservation of power at high altitudes. This will have the advantage of permitting the realization of a machine more maneuverable, although less powerful.

The interior arrangement should be complete and very comfortable.

The airplane will be designed for receiving, if necessary, two armored seats. The tanks will be protected or easily detachable. The airplane will have double controls or provided with an easy passage from the passenger's cockpit to the pilot's seat.

Armament.—The field of fire for the observer should be free to the maximum, particularly toward the rear and downward.

An arrangement should be provided for the installation of a floor gun shooting underneath and to the rear.

PURSUIT TYPE.	RECONNAISSANCE TYPE.
One or two machine guns, synchronized, or a cannon. Two machine guns joined together, on the tourelle, or an automatic cannon (in no case should such an airplane fly armed with two cannons). Five hundred cartridges per machine gun forward, 800 for the machine gun in the rear, 300 projectiles for the cannon.	A synchronized gun, two machine guns, connected together, on the tourelle, 300 cartridges each.

The forward machine guns can be either 7.65 or 11 millimeter.

Fuel.—Tanks for four hours' fuel for the motor turning at full power at sea level. One-fourth of the total capacity of gasoline will be contained in a removable tank provided with facilities for dropping quickly.

Equipment.—The airplane will be arranged to provide heat for the personnel and, eventually, the machine guns; the installation of an oxygen apparatus for the entire crew, an arrangement for Very pistols, and the installation of two parachutes.

PURSUIT TYPE.	RECONNAISSANCE TYPE.
The installation of photographic apparatus, moving picture or automatic. Eventually, interairplane telephones.	Installation of photographic apparatus, of 50 and 120, with a minimum of 100 plates. The installation of a ground glass for visual reconnaissance.

Characteristics.—Ceiling, 8,500 meters. Speed at 7,000 meters, 200 kilometers per hour; minimum speed at sea level, motor throttled and at most favorable angle, 110 kilometers per hour.

Military load, 400 kilograms.

In the military load are included only the pilot, the observer, the parachutes, machine guns, cartridges, machine-gun supports, airplane instruments, oxygen apparatus, photographic apparatus, heating arrangements and their supports, the ground glass and its support, the interplane telephone, and the container for the Very pistols.

Biplace pursuit and night reconnaissance.—Airplanes C. An. 2 type.

General requirements.—This airplane should not be cumbersome (maximum wing spread of about 15 meters).

It should be a very good glider, landing slowly, well balanced, easily maneuvered, and supersensitive fore and aft.

The visibility should be as good as possible, particularly toward the front and downward.

The pusher type is not prohibited.

The pilot and the observer, at the maximum distance, should be able to communicate by sight or voice without aviophone.

The airplane should have double controls or an easy passage from the observer's seat to the pilot's cockpit.

The motor will be furnished with an effectual silencer.

Tanks should be protected or easily detachable.

This airplane can be realized with motors of about 400 horsepower.

Armament.—Two or three machine guns, synchronized (caliber 7.65 or 11), firing 2,000 cartridges per minute; or, preferably, a machine gun and a cannon, two twin machine guns on the tourelle, or an automatic cannon.

No airplane will be equipped with two automatic cannons. One thousand cartridges per forward machine gun, 800 per machine gun on the tourelle, and 30 projectiles per cannon should be furnished.

Fuel.—Tanks for four hours' fuel supply for the motor turning at full speed at sea level.

Equipment.—The airplane will be arranged to provide heat for the personnel and, eventually, of the machine guns; night lighting and the use of a searchlight; installation of two parachutes; the installation of wireless (sending and receiving) with a view to regulating artillery fire; the use of instruments of goniometry; the installation of bomb flares; the installation of an arrangement for Very pistols.

Characteristics.—Ceiling, 6,000 meters. Speed at 2,000 meters, 195 kilometers per hour; speed, minimum, at sea level, motor throttled, at the most favorable angle, 90 kilometers per hour.

Military load, 400 kilograms and 450 kilograms if the armament includes a cannon.

In the military load are included only the pilot and observer, the machine guns, the cartridges, the machine-gun supports, the airplane instruments, wireless, heating apparatus, lighting apparatus, parachutes, and the instruments of goniometry, pistols, and signal guns.

OBSERVATION.

Biplaces, C. A. and divisional.—Airplane A. 2 and Ad. 2 type.

General requirements.—The airplane should be very maneuverable, and controls should offer a minimum of fatigue to pilot from sea level to 4,000 meters.

The span should not exceed 15 meters.

The airplane should have a very solid chassis and be so constructed as to resist bad landings.

It should have a speed range of two to one and should be able to take off very quickly.

The pilot and observer should be as close together as possible and should be able to communicate by voice and sight without aviophone.

The visibility of the pilot and observer should be studied from a standpoint of ground observation when at low altitudes.

It should have, if possible, a special adaptation of motor for divisional squadron types.

The airplane should be designed to accommodate two armored seats, dual control or passage facility from the observer's cockpit to pilot's cockpit, rubber-covered tanks or detachable tanks, and the control cables should be doubled with different points of attachment.

This type ought to be provided with a motor of from 300 to 400 horsepower.

Armament.—One synchronized machine gun, two tourelle machine guns, one floor gun shooting underneath and to the rear, 500 cartridges per gun, and removable bomb rack for 100 kilograms of bombs.

Fuel.—Three hours' fuel at sea level.

Equipment.—The airplane should have provision for wireless (sending and receiving), Klaxon warning apparatus, heat for the occupants and eventually of machine guns, oxygen installation, two parachutes, two Very pistols, and 20 Very pistol cartridges.

PHOTOGRAPHY.

AIRPLANE C. A.	DIVISIONAL AIRPLANE.
Installation provision for photographic outfit, vertical and oblique, 26 and 50 and for photographs, vertical, of 120, minimum of 50 exposures.	Installation provision for vertical and oblique photographic outfit of 26 and 50, and also for installation of automatic and moving-picture apparatus.

A folding observer's seat should be installed and also a container for message blanks at the disposition of observer.

The wireless installation and photo outfit installation should be compatible solely with the use of the wireless with direct excitation.

At all times for other wireless arrangements it is indispensable that the changing of these equipments will not require more than three hours for two mechanics.

Characteristics.—Ceiling, 6,000 meters. Speed at 2,000 meters, 200 kilometers per hour. Minimum speed at sea level, at most favorable angle, with throttled engine, 90 kilometers per hour.

Military load, 450 kilograms.

In these weights are included pilot, observer, parachutes, machine guns, oxygen apparatus, cockpit instruments, Very pistols, Very ammunition, photographic installation and supports, wireless outfit and heating outfit.

Armored two-place for divisional squadrons—Airplane type Ab. 2.

General requirements.—Type Ab. 2 should be very maneuverable. It should be capable of executing a complete figure "eight" at 100 meters between two points 100 meters apart without losing altitude.

It must be armored against normal shots fired at 300 meters range from underneath, behind, and from the sides.

It is understood that all equipment, including motor, motor accessories, radiator, and wireless, must be armored, also gas tanks, if not installed as per system of the Lanser type.

All control cables should be doubled and far enough away from one another throughout their length so as not to be severed by one projectile.

All vital members shall be studied to diminish risk of rupture from rifle fire.

The pilot and observer should be located as close together as possible and capable of communicating with each other by sight and voice without aviophone.

Visibility to both should be such as to permit good ground observation at low altitudes.

The plane should have dual controls, or facility for passage of observer to pilot's cockpit.

Armament.—One synchronized machine gun, two tourelle guns permitting of interplane combat fire or ground fire, one floor machine gun permitting firing underneath fuselage with good sighting, facilitating accurate ground fire, 500 cartridges per gun.

Fuel.—Two and one-half hours' fuel for motor running at full power at sea level.

Equipment.—This type should have arrangements for wireless (receiving and sending), auditory warning apparatus, heat for the occupants and eventually of guns, two Very pistols and ammunition. The comfort of the observer gunner should be specially studied, as for type A. 2.

This type should permit of installation of photographic apparatus, automatic or motion-picture (opening to be closed by removable armor plate).

Characteristics.—Ceiling, 4,500 meters. Speed at 1,000 meters, 180 kilometers per hour; minimum speed at sea level, motor throttled, at most favorable angle, 80 kilometers per hour.

Military load, 350 kilograms (armor not included).

In this military load are included only the equipment, machine guns, cartridges, supports and tourelles, cockpit instruments, Very pistols and ammunition, wireless apparatus, heating and photographic outfits.

Coefficient of safety in static tests, the same as for airplane type A. 2 under the same conditions.

BOMBARDMENT.

Biplace for day bombardment, long distance—Airplane Bp. 2 Type.

General requirements.—This airplane should be designed for group evolutions at an altitude higher than 5,000 meters.

Its speed should be little inferior to that of the biplace pursuit planes.

The motors should be furnished with self-starters.

Being given duties of long duration to accomplish, the pilot and observer should be comfortably installed.

A turning seat at a regulated height will be planned to permit the observer to see the sky and the ground while remaining seated.

The pilot and bomber, brought together as nearly as possible, ought to be able to communicate by sight and voice without the aviophone.

The airplane will carry double controls or else have easy passage from the passenger's post to the observer's.

The field of vision of the pilot and of the bomber will be particularly studied for group flying, for surveillance of the sky, and for the search for an objective. The field of vision forward on the vertical should be 45° for the pilot and 75° for the bomber.

Rip panels for the tanks and two armored removable seats should be provided.

Controls should be double, with different points of attachment.

Armament.—A machine gun, synchronized; two twin machine guns on the tourelle; 500 cartridges per gun: installation provided for floor machine gun, firing below and to the rear.

Bombs.—The airplane should be able to carry 200 kilograms of bombs with complete load of fuel. Besides, it should be arranged with removable bomb racks for a weight of projectiles corresponding to one-fourth of the fuel and weight of the removable tanks.

The bomb racks should be able to permit the easy change from one to the other of the following loads:

1. Entire load of bombs of 10 kilograms (incendiary or fragmentation).
2. Entire load of bombs of 50, 100, or 200 kilograms.

Fuel.—Tanks for seven hours' fuel for the motors at full speed at sea level, one or several tanks representing about one-fourth of the total capacity, should be easily removable.

Equipment.—The airplane should be arranged to permit vertical photography from 50 to 120; installation of an automatic or moving-picture camera for vertical photography or oblique toward the rear (for photographing the results of bombardment); heat for the pilot and passenger and eventually of the machine guns; installation of oxygen apparatus; two parachutes; and eventually of night lighting equipment and interairplane telephone.

Characteristics.—Ceiling, 7,500 meters. Speed at 5,000 meters, 190 kilometers per hour; minimum speed at sea level, at most favorable angle, with motor throttled, 90 kilometers per hour.

Military load, 580 kilograms.

In this military load are included only the pilot, observer, machine guns, cartridges, machine-gun supports, cockpit instruments, bomb racks, bombs, oxygen apparatus, parachutes, photographic and heating outfits, their supports, and interairplane telephones.

Biplace bombardment and attack—Airplanes BS. 2 type.

General requirements.—This airplane should not be cumbersome (wing spread of about 18 meters). It is not necessarily single-motored.

It should possess strong landing gear, capable of resisting bad landing fields.

The speed of its take-off should be sufficient for using improvised landing fields.

The one or two engines should be equipped with self-starters.

The pilot and observer should be as near together as possible and able to communicate by sight and voice without aviophone.

The airplane should carry double controls or should have easy passage from the observer's cockpit to that of the pilot.

Visibility for the pilot and observer should be perfect ahead and toward the ground.

Comfort and interior installation will be specially studied.

All controls should be doubled with separate points of attachment.

Tanks should be protected or easily detachable.

ARMOR.

BOMBARDMENT.	ATTACK.
Two removable armored seats.	Two removable armored seats, more removable armored plates protecting the engine underneath and the personnel against normal shots, resisting perforation at more then 400 meters altitude.

ARMAMENT.

BOMBARDMENT.	ATTACK.
A synchronized gun, two twin machine guns on the tourelle, installation provided for a floor gun firing underneath and toward the rear, 500 cartridges per gun.	For the use of the pilot: Two machine guns arranged for easy and effective attack on objects on the ground. For the use of the observer: Three machine guns permitting effective attack on objects on the ground, two or less of the machine guns should permit firing in aerial combat. Munitions supply should permit the execution of continuous firing for one minute.

The field of firing will be specially studied to permit firing toward the ground with easy aim on land objectives.

BOMBS.

BOMBARDMENT.	ATTACK.
The airplane should be able to carry 300 kilograms of bombs. The bomb racks should permit easy change from one to the other of the following loads: 1. Entire load of bombs of 10 kilograms. 2. Entire load of bombs of 25 and 50 kilograms.	The airplane should be able to carry 100 kilograms of bombs, fragmentation. These bombs can be released either by the pilot or the observer.

It is possible to adapt this type of airplane to the two different functions by providing for the installation of equipment necessary for the two types of work.

Fuel.—Four hours' fuel for the motors turning at full speed at sea level. One-fourth of the total capacity of gasoline should be contained in a tank which is easily removable. For missions of attack, this tank should be removed.

Equipment.—The airplane should be arranged to permit the installation of two parachutes, installation of an apparatus for Very pistols, heat for the occupants and eventually of the machine guns, the eventual installation of interairplane telephone and lighting outfits, automatic camera or motion-picture camera for vertical photography and at an angle toward the rear.

Characteristics.—Ceiling, 5,000 meters. Speed at 2,000 meters, 200 kilometers per hour; minimum speed at sea level, motor throttled, and at the most favorable angle, 100 kilometers per hour; time of climb to 3,000 meters, 20 minutes.

Military load, 720 kilograms (armor not included).

In this military load are included only the equipment, machine guns, cartridges, supports and tourelles, bomb racks, view finders, cockpit instruments, Very pistols and ammunition, heating and lighting apparatus, and interairplane telephone.

Triplace for protection of day bombardment—Airplane Bpr. 3 type.

General requirements.—This airplane is intended for close protection of bombardment airplanes, type BS.2 or Bp.2, and eventually of airplanes, type A. 2, observation.

It should possess the maneuverability indispensable to an airplane which will have to sustain defensive combats.

It should have great speed of take-off for facilitating its missions of protection.

Its armament should be very powerful, its field of fire perfectly free. Three removable armored seats should be provided, tanks should be protected or easily detachable. Controls should be double with separate point of attachment.

The airplane should have double controls for use of one of the observers or easy passage from the gunner's post to that of the pilot. One of the gunners should be placed as near as possible to the pilot (communication by voice without aviophone).

The motors should be furnished with automatic starters.

Armament.—Twin machine guns on the tourelle forward with field of fire toward the rear, firing at a minimum of 15° above the horizontal (in line of flight): twin machine guns on the rear tourelle: two machine guns, twin, firing under the fuselage toward the rear, with a window permitting aim and sight in this direction; 500 cartridges per gun.

One of the pair of machine guns can be replaced by an automatic cannon.

This airplane will not carry bombs by reason of its armor. The removable bomb racks, however, ought to allow a contingent load of 250 kilograms.

Fuel.—Six hours, of which one-third is in the tanks which are easily removed.

Equipment.—The airplane will be arranged to permit vertical photography and oblique toward the rear with automatic or motion-picture camera, heat for the pilot and passengers and eventually of the machine guns, the installation of Very pistols, three parachutes, eventually interairplane telephones and lighting outfits.

Characteristics.—Ceiling, 7,500 meters. Speed at 5,000 meters, 210 kilometers per hour; minimum speed at sea level, motor throttled, and at the most favorable angle, 100 kilometers per hour.

Military load, 520 kilograms without the armor.

In this military load is included only the pilot, passengers, machine guns, cartridges, supports and tourelles, oxygen apparatus, cockpit instruments, heating apparatus, photographic outfits and their supports, parachutes and interairplane telephones.

Biplane, lightly loaded for day bombing and combat.—Airplane type Bn.2.

General requirements.—This airplane should be relatively of small bulk (wing spread of about 20 meters).

It should be a good glider, well balanced, automatically placing itself in descent or ascent according to the variations of the operation of the motors.

It should be furnished with strong landing gear, should have great speed of take-off from the ground in order to be used at need on improvised landing fields.

Visibility should be perfect toward the front and below. Pusher type motor is not prohibited.

The pilot and observer should be as close together as possible and should be able to communicate by sight and voice without aviophone.

The airplane should carry double controls or should have easy passage from the cockpit of the observer to that of the pilot.

The motors should be easily managed, sure, and silenced.

Intended for bombarding unprotected targets, it should be able to descend very low for the bombardment and to zoom up and climb rapidly.

Tanks should be protected or easily detachable.

Armament.—Two twin machine guns on the tourelle for use of the observer; a machine gun firing below, toward the rear; 500 cartridges per gun. The machine guns should permit firing upon objects on the ground.

The airplane should be able to carry 500 kilograms of bombs with four hours' fuel: besides, it should be furnished with removable bomb racks for a weight of projectiles corresponding to one-fourth of the fuel; the bomb racks should permit the easy change from one to the other of the following equipments:

1. Entire load of bombs of 50 kilograms each.
2. Load of bombs, half of 10 kilograms and half of 50 kilograms.
3. Load of bombs, half of 50 kilograms and half of 100 kilograms.

Fuel.—Tanks for four hours' fuel for the motors turning at full speed at sea level.

Equipment.—The airplane should be arranged to permit lighting for night and, eventually, the use of a searchlight for landing, heat for the crew and, eventually, of the machine guns, installation of two parachutes, use of the apparatus of goniometry, installation of bomb flares, installation of an arrangement for signaling by Very pistols.

Characteristics.—Ceiling, 4,000 meters. Speed at 2,000 meters, 150 kilometers per hour; minimum speed at sea level, motor throttled, and at the most favorable angle, 80 kilometers per hour.

Climb to 2,000 meters in 20 minutes.

Military load, 940 kilograms.

The military load comprises only the crew, machine guns, cartridges, supports, tourelles, bomb racks, view finders, cockpit instruments, heating and lighting apparatus and that of goniometry, Very pistols and ammunition.

Heavily loaded multiplace for long-distance night bombardment—Airplane Bn. 4 type.

General requirements.—Designed for carrying the greatest load possible a distance of 200 kilometers. Mobility is a secondary quality. The wing spread is not limited, provided the wings are easily demountable to permit the shelter of the airplane under a hangar 26 by 28 meters.

The airplane should be equipped for four people—a pilot, a pilot's aide, a bomber, and a mechanic. A runway in the fuselage should permit easy passage from one post to another.

The airplane should be at least trimotored and should be able to take off with one motor cut out. The motors should be accessible in flight.

It should be furnished with an effective silencer and an automatic starter.

The field of vision ought to be perfect, especially toward the front and below.

Tanks should be protected or easily detachable.

Armament.—Two machine guns upon the forward tourelle; two machine guns on the rear tourelle; two machine guns under the fuselage toward the rear, with a window permitting sight and aim. Five hundred cartridges per gun.

The supports of the machine guns should permit firing at objects on the ground.

The airplane should be able to carry 1,500 kilograms of bombs when it carries only six hours' fuel. Besides, it should be furnished with removable bomb racks for a weight of projectiles corresponding to one-fourth of the gasoline and to the weight of the removable tanks.

The bomb racks should permit of easy change from one to the other of the following equipments:

1. Entire load of bombs of 100 and 200 kilograms.
2. Load, half of bombs of 50 kilograms and half of bombs of 100 and 200 kilograms.
3. Load with three bombs of 500 kilograms.
4. Load of one bomb of 1,000 kilograms and one bomb of 500 kilograms.

Fuel.—Tanks for seven hours' fuel for the motors turning at full speed at sea level; one or several tanks, representing about one-fourth of the total capacity, should be easily removable.

Equipment.—The airplane should be arranged for permitting lighting for night and the use of a searchlight for landing; heat for the crew and, eventually, the machine guns; installation of four parachutes and of wireless (receiving and sending); the use of apparatus of goniometry; installation of bomb flares; and an arrangement for Very pistols and ammunition.

Characteristics.—Ceiling, 4,500 meters. Speed at 2,000 meters, 150 kilometers per hour; minimum speed at sea level, motor throttled, and at most favorable angle, 80 kilometers per hour. Climb to 2,000 meters in 20 minutes.

Military load, 2,220 kilograms.

In the military weight are included only the crew, machine guns, cartridges, supports and tourelles, bomb racks, bombs, view finders, cockpit instruments, heating and lighting outfits, wireless and goniometry, pistols and Very pistols.

Colonial type airplane.

General requirements.—The airplane ought to have an easy landing and to realize a sufficient speed at the altitude of use in order not to be troubled by normal winds.

Its radius of action ought to be extensive on account of the cost and the difficulties of establishing refueling stations.

It should be able to be transformed quickly into a bombardment plane.

Its construction should be particularly looked after and one should seek specially—

1. Good preservation in normal conditions of temperature and of hygrometric degree, either the temperatures currently reaching 40° and 1 hygrometric degree variant of 30 to 35 in western Africa to 70 to 90 in the other colonies.
2. Absolute interchangeability of demountable parts and, if possible, of part assemblies.
3. Maintenance and easy repair.
4. Bulk reduced for transport (ease of assembly and disassembly).
5. Very solid landing gear and pneumatic tires resisting the special conditions of temperature and humidity.

Motors can be cooled by air or by water, taking account, in their choice and their mounting, of the special conditions of their functioning and their preservation—temperature, humidity, sand, etc. They should be strong, easy to repair and maintain, and easy of access.

The airplane should be polymotored and should be able to continue its mission with one motor cut out. The motors should be very easy to start.

Armament, contingent.—Two machine guns, front, movable, firing downward; one machine gun, rear, firing downward; 500 cartridges per gun.

The airplane should be equipped to carry 300 kilograms of bombs of 10 kilograms each.

Fuel.—Six hours for motors at full speed at sea level.

Equipment.—The airplane should be arranged to permit night lighting, installation of one parachute for the observer, installation of wireless (sending and receiving), and one photographic apparatus of 50.

Characteristics.—Ceiling, 4,500 meters with full load. Speed at 2,000 meters, 160 kilometers per hour; minimum speed at sea level, 70 kilometers per hour.

Military load, 750 kilograms.

The machine should be able to take in eight persons, flight equipment included. Arrangement should be provided in consequence.

GENERAL REMARKS.

Power of fire.—It is well understood that the directions given on the number of machine guns constituting the armament exacted are valued only as an indication of the power of fire exacted.

If a single machine gun lighter than two Lewis guns can give the same power of fire with the same safety of functioning, the constructor can propose its adoption. The unit of comparison adopted is, for the forward guns, the Vickers; for the rear guns, the Lewis.

Armor.—The armored seats and removable armor plates should be studied in such a fashion as to obtain the maximum safety without surpassing a weight of 50 kilograms per person or per motor.

Radiators for the machine guns.—The machine guns intended for firing upon objects on the ground, on the airplanes of types A. 2, BS. 2, or Bn. 2, should be provided with special radiators around the barrel of the gun, permitting it to fire long series of cartridges without risking the deterioration of the gun.

FRENCH AERODYNAMIC STUDIES.

Aerodynamic studies have been given considerable more importance throughout Europe since the war. The French are conducting their aerodynamic experiments at the present time in the wind tunnel at the Eiffel Tower and at the old St. Cyr Tunnel. Both places offer fairly good facilities for the conducting of aerodynamic tests. The Eiffel Tower Tunnel is well known and complete description of the St. Cyr Tunnel is available among our technical files.

A new aerodynamic station is being constructed at Issy des Moulineux, which is located on the outskirts of Paris. The entire station is constructed of brick and steel and will have adequate facilities for the conducting of aerodymanic tests and all kinds of experimental work. Provision has also been made to have a flying field available in the near future, adjoining this station.

A large headquarters, hangars, engine test stands, dynamometers, and buildings to house every known device for testing materials, have been constructed. However, by far the most interesting building on this station is the one which houses the new wind tunnel.

This tunnel is located in a building of brick and steel about 210 feet long and 100 feet wide. Plenty of windows and large skylights have been incorporated in the construction in order to have plenty of light. A large pit, about 8 feet deep, lined with cement, takes up the entire floor space of the building, with the exception of the gangways along the sides and ends. Next to this building is another one of similar construction, built to house the engines that will furnish the electrical energy to supply the tunnel.

The tunnel itself is of the Eiffel type and is entirely constructed of reinforced concrete. It was built in accordance with the design of the aerodynamic section of the French technical service and was constructed by the company of which Mr. Caquot, formerly of the technical section, is the head. The tunnel is supported by two huge concrete walls running longitudinally along the entire length of the tunnel. This leaves a free air space under the tunnel.

The entrance nozzle is set high up from the floor and back from the walls of the building. The section of the outer walls of the collectors has been made square instead of circular, and of a width equal in diameter to the front end of the collector. This permits the outer walls of the collector to be parallel to the walls and floor of the room and eliminates any break of contour caused by the experimental chamber. Aft of the experimental chamber the outer walls are gradually faired into the diffuser.

The diameter of the tunnel is 3 meters at the throat and 7 meters at the propeller end. It is to be driven by a six-bladed propeller. The section of each blade is to be exactly analogous to the arc of a circle. It will be possible to vary the pitch of the blades of the propeller, but this can not be done while it is in motion. The propeller will be driven direct by a 1,000-horsepower electric motor which will permit a speed of approximately 260 feet per second to be attained.

Behind the diffuser is a concrete stand for the motor. In order to change the direction of the air leaving the diffuser, the two forward faces of the stand are curved in the plane. It is proposed to continue these curves upward and outward by wooden partitions.

Entrance into the experimental chamber is gained by means of a passage with a staircase inside of one of the supporting walls of the tunnel. The passage is equipped with two steel doors to insure an air lock. The experimental chamber itself is very large, being roughly cubical, about 20 feet to a side. The diffuser ends and the collector project into the experimental chamber.

The only natural light in the chamber is that which comes through the collector.

The floor is equipped with a square trap closed by a movable platform. When it is desired to work with large models the movement of a lever lowers the platform sufficiently for it to come into contact with a track mounted on the inner faces of the two longitudinal walls below the tunnel. It can then be pushed back and out of the way and the large model admitted into the experimental chamber.

The tunnel is so designed that it can be partially or completely closed at the throat if desired.

A number of hooks have been imbedded in the concrete, flush with the surface of the diffuser and collector cones near the throat. These hooks can be pulled outward and to them the supports of smaller cones can be fastened. This will produce a tunnel 2.6 feet in diameter, concentrically placed within the larger tunnel. By using a small propeller and the power available for the large tunnel the French expect to obtain a speed of 1, 300 feet per second.

The method of suspending the model will be by wires instead of by a spindle as is generally practiced. It is understood that the balance will be of the dynametric type with various gauges to which the wires supporting the model will be attached.

The French hope that this tunnel will be used as standard and all other tunnels in France and, if possible, in the world, may receive correction factors based upon this particular tunnel in order to have a uniform system of measure for procuring aerodynamic information. This tunnel is unquestionably the most elaborate tunnel in existence to-day and very accurate results will probably be procured when it is put into operation.

The equipment at the St. Cyr Tunnel is very similar to that found in the laboratory of the National Advisory Committee of Aeronautics at Langley Field. However, they have several pieces of apparatus which are not used in this country, including a large whirling arm which can be used for propeller testing and procuring certain other information.

The most ingenious device installed, however, is a track for the testing of full-scale machines. A track about a mile in length has been built and carefully graded. The models are placed on a car equipped with facilities for measuring their aerodynamic balance at the various pressures. The car is supplied with electric power by a rail 16 inches above the ground on each side of the track. After allowing for acceleration and retardation, there is a useful run of about 1,650 feet, during which the readings are made showing the lift and drag values as well as the relative speed. The French claim to have procured some very interesting and useful data from experiments with this device.

WIBAULT DESIGN DRAFTING SYSTEM.

The Wibault Co. uses the system of designating their drawings which has been prevalent throughout France and England for several years. The idea is to simplify the number of drawings that are necessary to carry out the construction of experimental machines and to provide a simple means of designating drawings that will show their relation to the entire assembly.

A single sheet contains a drawing on a reduced scale of the unit to be constructed with part numbers attached and

Plan : N° 2205

Pièces de mesures N°s 3-4-5

Pièces [illegible] de mesures N°s 3-4-5

Numéros		Nombre	Désignation	Dimensions D	Dimensions G	Dimensions S	Nature de la Matière
[illegible]	[illegible]	[illegible]	[illegible]		15/10		Aluminium
[illegible]	[illegible]	[illegible]	[illegible]		〃		〃
[illegible]	[illegible]	[illegible]	[illegible]		〃		〃
[illegible]	[illegible]	[illegible]	[illegible]		〃		〃
[illegible]	[illegible]	[illegible]	[illegible]		〃		〃
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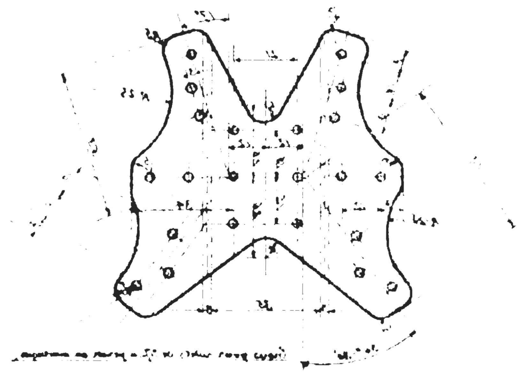
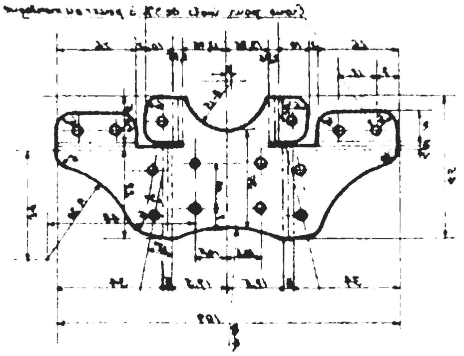
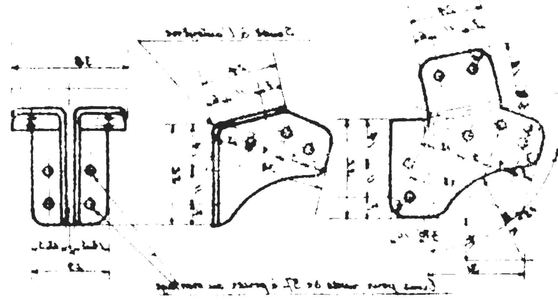
Pièce : N° 36019 (Aluminium -15/10)



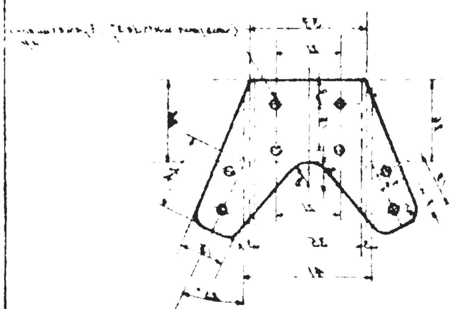
Pièce : N° 36022 (Aluminium 15/10)



Pièce : N° 36020 (Aluminium -15/10)



Pièce : N° 36023 (Aluminium 15/10)



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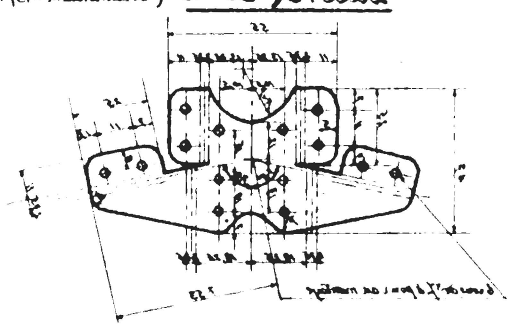
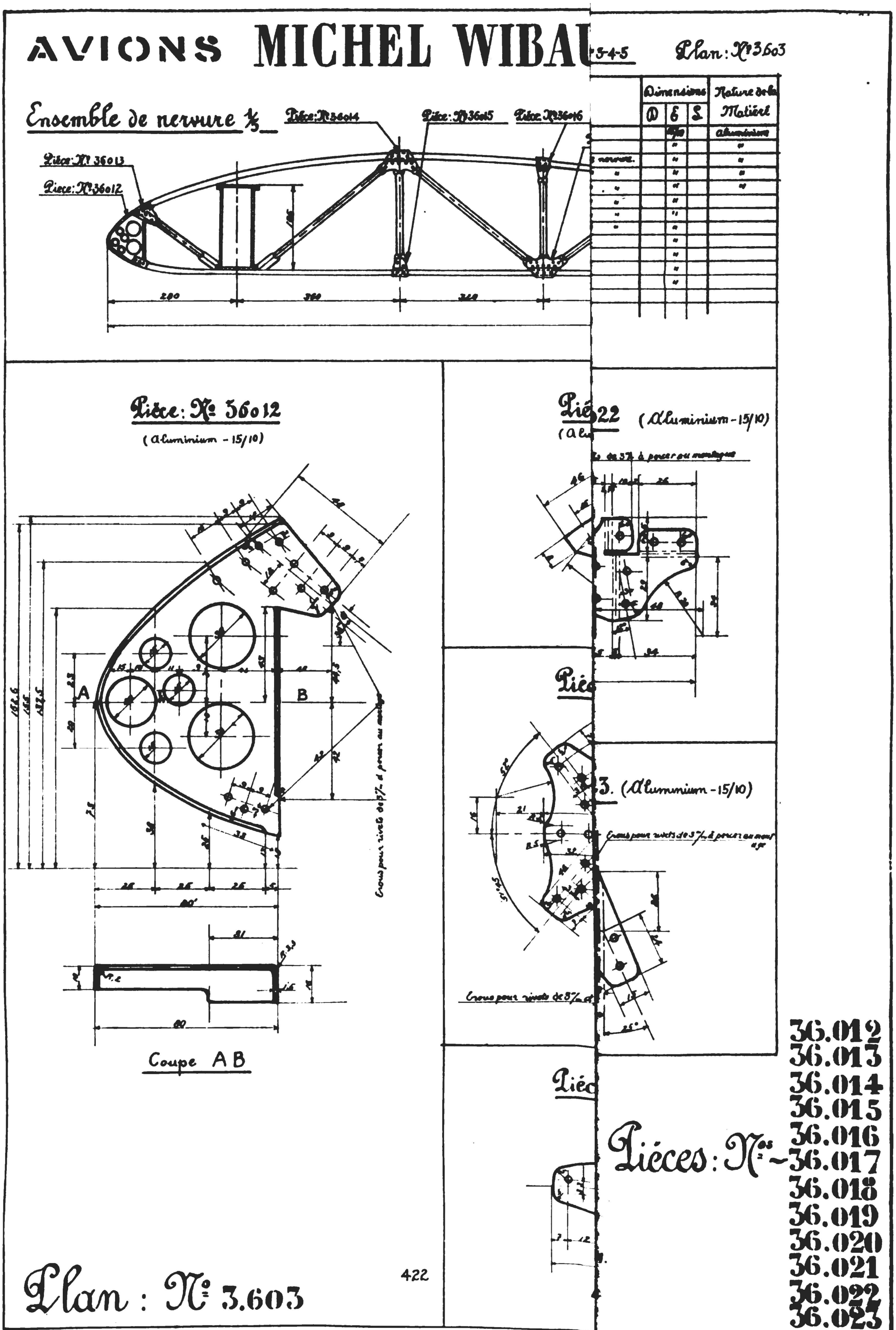


Pièces : N°s

Dessiné
Calqué
Vérifié

Paris le 14 Sept 1911

36.012
36.013
36.014
36.015
36.016
36.017
36.018
36.019
36.020
36.021
36.022
36.023



14799—23. (Faces p. 27).

their frame rectangular outlines which are contained in numerical subdivisions of the sheet. These rectangular subdivisions contain detail drawings of specific parts. They are supposed to contain only the amount of information absolutely essential to carry out the experimental design. Figure 1 is a specimen of this type of design drawing which illustrates the principle involved. The first number on all design drawings and on all the detail drawings is explanatory of the type of aircraft to be constructed. For instance, in Figure 1 No. 3 C represents the third type of pursuit (chasse) by Mr. Wibault. Drawings Nos. 301 to 399 are the main assembly drawings which show, respectively, all the different installations. Other numbers are allocated to unit designs as follows:

Nos. 101 to 199 are numbers allotted for the fuselage drawings.

Nos. 201 to 299 are numbers allotted to the empennage, tail skid, and landing gear.

Nos. 301 to 399 represent the numbers that are allotted to armament and supercharger installations.

Each of these numbers is preceded by a three and a decimal point to indicate the ship to which the drawings pertain.

In addition to the hundred numbers allotted for the assembly drawings, 1,000 numbers are allotted for detail drawings. An example of this is in the assembly rib drawings, part No. 3603 (see fig. 1), which is understood to include in the assembly all the pieces as Nos. 36.012 to 36.023.

In the upper right-hand corner of the drawing is the nomenclature and gauge of the material and number required. In the lower left-hand corner is the number of the assembly. In the lower right-hand corner are the drawing numbers of the details illustrated on the sheet. All the nomenclature titles are of uniform type with respect to numeral, designation, spacing, and size, which facilities ease in identification and simplifies routing in the shop.

BLERIOT-SPAD-HERBEMONT AIRCRAFT.

The Bleriot-Spad-Herbemont Co. has been busily developing the following types since the war:

S–20. Mono-biplace pursuit; three machine guns; 300 horsepower; Hispano-Suiza. (August 7, 1918.)

S–15. Monoplace; touring; 80 horsepower; Le Rhone. (May 18, 1919.)

S–28. Monoplace; 300 horsepower; Hispano-Suiza. (September 26, 1919.)

S–27. Triplace (touring limousine); 275 horsepower; Hispano. (November, 1919.)

S–30. Monoplace touring; 45 horsepower; Anzani. (January, 1920.)

S–29. Biplace touring; 80 horsepower; Le Rhone. (January, 1920.)

S–38 bis. Biplace; 300 horsepower; Hispano. (February, 1920.)

S–26 and 26 bis. Speed and altitude hydroplanes; 275 horsepower; Hispano. (March, 1920.)

S–31. Hydroplane; 275 horsepower; Hispano. (April 10, 1920.)

S–32. Special altitude airplane; 200 horsepower; Damblanc Mutti. (June 10, 1920.)

S–33. Berline (8-place); 310 horsepower; Salmson, AZ-9.

S–33 bis. Berline (6-place); 275 horsepower; Salmson, Z–9.

S–34. Biplace; training, with double controls; 80 horse power; Le Rhone. (July 16, 1920.)

S–35. Mono-biplace pursuit; 180 horsepower; Hispano.

S–37. Four-place transport; 275 horsepower; Hispano. (September 9, 1920.)

S–20 bis. Monocoque special; Gordon-Bennett; 300 horsepower; Hispano. (September 22, 1920.)

S–20 bis. Monocoque; record speed (special profile); 320 horsepower; Hispano. (October 6, 1920.)

Of these types the most notable are the Spad 20, the Spad 20 bis, and the Spad 34 and 35.

SPAD 20 TWO-SEATER PURSUIT.

The Spad 20 is the 300-horsepower Hispano motored, two-place, and was designed in 1918 by Mr. Herbemont.

Characteristics:

- Motor, 300 horsepower Hispano; radiator, nose-type.
- Gasoline tanks: One under pilot's seat and two gravity tanks on the upper wings.
- Over-all length: 7.30 meters.
- Height: 2.8 meters.
- Wing span, upper: 9.72 meters.
- Wing span, lower: 8.69 meters.
- Chord, upper: 1.75 meters.
- Chord, lower: 1.65 meters.
- Gap, at center: 1.65 meters.
- Gap, at ends: 1.55 meters.
- Total area: 30 square meters.
- Weight, loaded, per square meter: 43.7 kilograms.
- Weight, per horsepower: 4.4 kilograms.
- Endurance, at 3,000 meters: 3 hours.
- Ceiling: 7,000 meters.
- Weight of wings, per square foot: 1 pound.

Performance:

- Speed at 2,000 meters: 270 kilometers per hou .
- Speed at 5,000 meters: 210 kilometers per hour.
- Climb to 2,000 meters: 6.6 minutes.
- Climb to 3,000 meters: 10.7 minutes.
- Climb to 5,000 meters: 25.65 minutes.
- Minimum flying speed: 107 kilometers per hour.
- Weight, empty: 1,863 pounds.
- Useful load: 1,010 pounds.
- Total weight: 2,873 pounds.
- Gasoline: 335 pounds.
- Oil: 37 pounds.
- Equipment: 352 pounds.
- Armament: 205 pounds.
- Miscellaneous: 35 pounds.
- Tank protection: 54 pounds.

This machine represents the best performing two-place job that the French have in their air service. It has been built in numbers and is being used to quite an extent along the French-German frontier. The mounting of the Hispano motor is unique from the standpoint of its rigidity and the effectiveness with which the vibration is absorbed. It is very inaccessible, however, and the motor must be pulled from the front of the fuselage in order to get it out of the machine. The only accessibility is derived from two removable pieces of cowling on each side of the fuselage.

The top longerons extend directly over the motor. To them the center section struts are fastened. The fuselage is built of the famous Spad monocoque construction. Mr. Herbemont claims that the advantages of the monocoque construction are as follows:

1. Absolute freedom from deformation even after long service and numerous landings.
2. Extreme lightness.
3. Simplicity of construction, reduction in the number of materials, and economy in repair.
4. Absolute interchangeability of monocoques.
5. Reduction in head resistance.
6. Facility in dismounting motor. No derangement of the fuselage occurs and the motor can be quickly removed.
7. Accessibility to all parts of motor.
8. Construction affords pilot almost complete visibility and reduces to a minimum parasite resistance.

Of course, it will be inferred that these claims are questionable in many respects. This type of construction would be best where dynamic interpretation of outline would be an advantage and where extreme climatic changes are not prevalent.

However, this machine, with the Nieuport 29, represent the finest streamline pursuit jobs in Europe. This machine has been interpreted in another type, a single-seater pursuit, with two machine guns and having a total load of 358 kilograms. The ground speed of this type was 236 kilometers per hour.

Climb to 5,000 meters: 17 minutes 45 seconds.
Climb to 6,000 meters: 26 minutes.

SPAD HERBEMONT RACING TYPE.

This is a modified Spad Herbemont S-20 with a different wing structure and with the further adaptation of cleanliness in exposed detail design with the object of diminishing resistance. The wing area in this type is 14 square meters.

Total weight: 1,050 kilograms.
Weight of load: 200 kilograms.
Motor: 320-horsepower Hispano.
Load per horsepower: 3.28 kilograms.
Load per square meter: 76 kilograms.

This machine has realized 309 kilometers per hour over a 4-kilometer course.

BLERIOT COMMERCIAL AIRPLANE, SPAD TYPE 45.

General characteristics:

Biplane with two tractor screws and two pushers.
Four 275-horsepower naval type Hispano-Suiza engines.
Span: 70.5 feet.
Length: 50.2 feet.
Height: 19 feet.
Wing area: 1,560 square feet.
Weight, empty: 7,700 pounds.
Fuel load: 3,080 pounds.
Passengers, luggage, etc.: 4,620 pounds.
Total weight: 15,400 pounds.
Load per square foot: 9¼ pounds.
Load per horsepower: 14 pounds.
Speed: 124 miles per hour.
Endurance at full power: 5 hours.

The Spad 45 is a transport airplane, with four 275-horsepower Hispano-Suiza engines, designed to carry 17 passengers and a crew of 3.

In the nose of the fuselage is the station of the navigator with the wireless telegraph, signal, and navigation instruments. Aft of the navigator and forward of the wings are two pilots placed side by side and having good visibility. Behind the pilots and at the center of gravity, between the planes of rotation of the forward and aft propellers, a large cabin is arranged for 15 persons. Under the floor of this cabin there is a large luggage hold containing a mechanic's seat. While the machine is in flight the mechanic can visit the two engine nacelles to make small repairs. Aft of the main cabin there is a lavatory and a double seat permitting two passengers to travel in the open air.

The central part of the cellule has forward stagger, the swept-back upper plane being 3.3 feet forward of the lower plane at the center. The lower plane is in three parts with a straight leading edge. Two symmetrical ailerons, controlled by a lever and crank arrangement, are placed at the outer rear corners of the lower plane.

The two planes, 10.6 feet apart, are connected by two struts (one on each side of the fuselage). To reduce head resistance, the bracing wire terminals are in the thickness of the wings.

The monocoque fuselage is composed of two layers of strips of tulip wood, 20 millimeters in thickness, and and one layer of spruce, 40 millimeters thick, covered with fabric on the outside.

The landing gear is composed of two vees of several thicknesses of hardwood and covered with fabric. These vees are connected at their lower end by two steel tubes between which lies the divided axle. There are two wheels arranged in tandem attached to each end of the axle by a special mounting permitting the contact of all four wheels with the earth regardless of the irregularities of the terrain. A strut runs from each side of the landing gear to the lower wing directly under each engine nacelle. The wheels are 1,000 by 180 millimeters (3.28 by 0.59 foot). Streamline wire cross bracing assures the rigidity of the structure.

The ash skid attached to the rear of the fuselage is in two parts, an upper fixed portion and a lower pivoted portion. The latter has a rubber shock absorber and a steel skid.

The rudder and elevator are connected to the controls by steel cables in duplicate.

The stabilizer and fin are adjustable in flight.

The four engines are arranged in two groups of two in tandem and are placed on the lower plane on each side of the fuselage.

The engine nacelles are easily removable and thus permit the use of any engine, and the nacelles are interchangeable. Repairs are very easy and are made at the workshop on complete nacelles removed from the airplane. In case of engine failure, the entire engine nacelle may be changed in a few minutes by removing a few bolts.

NEW PURSUIT SHIP.

The Spad Co. has designed and are building a single-seater, 300-horsepower Hispano motor, monocoque, high-altitude machine, supercharged with a Rateau super-

charger. It is impossible to get any characteristic data on this machine, but we saw the fuselage and landing gear for this type in the Bleriot factory under construction. The fuselage is smaller in cross-sectional arrangement than the Spad 30 and is much shorter. There is no doubt but that this machine with the superchargers ought to have a very superior performance as a high-altitude single-seater. It is of the conventional Herbemont biplane, single-strut type with bottom wing ailerons.

The trials of this machine ought to be followed very closely as soon as developments have warranted its test flights. Supercharger installation is very neatly carried out and is mounted in such fashion as not to add excessive head resistance or obstruction of vision. A semicircular copper air leader is located just below the fuselage in back of the propeller.

NEW OBSERVATION MACHINE.

A two-seater Herbemont observation type is also being built with superchargers. The motor mounting, however, is different from the conventional type, inasmuch as it is of cantilever steel tube type. It is in a monocoque fuselage, thus rendering an accessible motor installation possible with all the advantages of monocoque streamline construction. This machine represents one of the latest departures in two-seater, supercharged observation type development and its trials and performances should be closely watched. The performance of this machine should be compared to the Breguet Sesquiplan. It is noteworthy that on most of the latest Herbemont machines, Lamblin water-cooling systems are in vogue.

SPAD, MARINE TYPE.

Another Spad machine has been undergoing trials and one model which was in the Bleriot shops for improvements was the Spad 20, remodeled as a marine type.

The principal characteristics of this machine are:

Span: 10.47 meters.
Length: 7.90 meters.
Total weight: 1,488 kilograms.
Weight per horsepower: 5.4 kilograms.
Area: 33 square meters.
Weight, empty, with water: 1,028 kilograms.
Weight per square meter: 45 kilograms.

The principal departure of this machine from the conventional type was the adoption of a landing gear pontoon with streamline section in place of the conventional hydrovane that is customarily used on machines of this type.

This machine is approximately 100 kilograms heavier than the land type and with about 10 kilometers less speed.

The French marine service demands characteristics of performance as follows:

Climb to 2,000 meters: 15 minutes.
Useful load: 470 kilograms.
High speed: 200 kilometers per hour.

This machine climbed to 2,000 meters in 14 minutes and made a high speed of 211 kilometers per hour. It was a very remarkable performance for this type of machine, considering the added chassis resistance. It closely resembles the regular Spad Herbemont 20 job.

SPAD HERBEMONT S-34—DUAL CONTROL.

This machine has been designed as a side by side training plane. The fuselage of this machine is not built of the characteristic Herbemont monocoque construction, but of the regular stick and wire construction. It is rectangular in shape.

Characteristics are as follows:

Total area: 20 square meters.
Length, over all: 6.40 meters.
Span: 8.15 meters.
Height: 2.36 meters.
Weight, empty: 370 kilograms.
Total load: 590 kilograms.
Motor, Le Rhone: 80 horsepower.
Speed near ground: 145 kilometers per hour.

This is a very interesting training type and the visibility for both pilot and student is very well worked out in this design. The job on a whole is a very good manufacturing proposition and is equally well designed for maintenance in the field. It is of the single-strut, single-bay type. The disposition of instruments and controls in the common cockpit is ingeniously carried out. Several of the French pilots seem to be very much in favor of this type of machine for training purposes.

SPAD BERLINE TRANSPORT, TYPE S-33.

This machine has been designed to carry seven passengers. It has a very comfortably designed cabin arrangement for the passengers. Its fuel capacity is 6 hours at 190 kilometers per hour. The passengers' cabin is placed directly over the center of gravity of the machine, behind the motor and in front of the pilot. This tends to offset the rolling characteristic so often found in airplanes with a load situated far back. It also permits the machine to fly with only a percentage of the total number of passengers without throwing the machine out of balance and without making it necessary to modify the tail setting. The passengers all sit in the machine facing toward the front. The entering door to the cabin is located near the front. This job is geometrically similar to the Spad 20 and is of monocoque construction.

Characteristics of this machine are as follows:

Tractor biplace motor, Salmson AZ 9: 310 horsepower.
Weight, empty: 1,000 kilograms.
Total weight: 1,900 kilograms.
Span: 11.664 meters.
Length: 9.88 meters.
Height: 3.2 meters.

THE NIEUPORT AIRPLANES.

The Nieuport Co. is one of the most important aeronautical combinations in France. They are building a great number of machines and earning enough to carry out an active development program. This concern built large numbers of machines during the war, especially of the XXVII and XXIII types.

As stated in the résumé, they are still confining themselves to the stick-and-wire construction with their characteristic monocoque fuselage.

NIEUPORT XXIX C–1.

The Nieuport XXIX C–1 is the famous standard pursuit plane of the French air force and unquestionably is a masterpiece. It has been especially designed for combat work under conditions found in France and has a wonderful combination of the best qualities of speed, climb, and maneuverability.

The characteristics are as follows:

Length: 6.5 meters.
Span: 9.7 meters.
Area: 27 square meters.
Motor: 300 horsepower Hispano.
Weight, empty: 761 kilograms.
Fuel weight: 172 kilograms.
Useful load: 167 kilograms.
Total weight: 1,100 kilograms.
Endurance: 2 hours.

The performance is as follows:

Speed at ground: 266 kilometers per hour.
Climb to 6,000 meters: 18 minutes 46 seconds.
Ceiling: 8,500 meters.

This machine is of the monocoque construction, of the type first evidenced in the Nieuport XXVIII monoplace. It represents, for its load, the best performing single-seater in France. It is featured primarily by its fuselage outline of superior aerodynamic qualities to any other European machine.

The method of construction of the monocoque is of primary interest, inasmuch as this type of construction, even though it is of wood with the ordinary advantages and disadvantages of wooden construction, permits the realization of the best shape. The shell is built entirely in one integral unit on a longitudinally collapsible wooden form. The diameter of the fuselage is approximately 32 inches at the master section. The fuselage sections proper throughout all transverse sectional stations from nose to stern are circular in section. This facilitates the construction of the fuselage form to a marked degree. The form can be withdrawn in conic sections from the front of the fuselage. The shell is constructed of plies of tulip wood approximately 1 millimeter thick and from 1 to 2 inches wide, wrapped in transverse, biased fashion around the form. The form is first covered with light-weight brown paper to prevent adhesion of the glue from the shell layers to the form itself.

Centrally located in an axial sense is a mandrel to which fuselage-form sections are fastened. It is supported at its extremities on V-shaped borings mounted on wooden floor horses. This convenience facilitates rotation of form throughout range of 360° to enable the women workers to completely wrap fuselage in single cycle operation. Five hundred and fifty women-hours are required to make a complete Nieuport fuselage shell, exclusive of interior trusswork for cockpit and motor compartment sections. The trusswork aft, which consists of 10 triangular longitudinals and annular ring veneer ribs, is assembled on the form before the shell is built around it.

The stabilizer, as well as the top and bottom fin, is built in monocoque fashion integral with the fuselage. The elevators and rudder are of conventional construction. The tail unit is devoid of any external bracing. The wings are of the combination two-bay truss type with counter-balanced ailerons on the bottom wing only.

The cooling system uses Lamblin radiators which allow a better streamline fuselage form with proper entry shape which is so hard to procure with the conventional type with nose radiators or ordinary radiators in free-air position in close proximity to the fuselage. The bad effects of radiator interference are reduced to the minimum. The Lamblin radiators are mounted in a free-air position in the region of maximum air velocity. They are placed in the two vees of the undercarriage and the deflection of air flow from its natural course of both radiator and fuselage is practically nil.

This machine has exposed gun mounts and a detachable gasoline tank immediately forward of the pilot, between him and the engine. The oil tank is situated directly under the motor and has a Lamblin-type oil radiator. This machine has further been made into a high-altitude type with a Rateau supercharger. Two hundred of these machines are now being constructed by the Nieuport Co. for the French Army air service.

NIEUPORT DELAGE SESQUIPLAN.

This machine is the famous Nieuport racer. The general characteristics are as follows:

Total length: 6.1 meters.
Height: 2 meters.
Span: 8 meters.
Chord: 1.5 meters.
Area total wing: 10 square meters.
Area landing gear plane: 1 square meter.
Total area including 1.4 square meters for ailerons: 11 square meters.
Stabilizer: 1.28 square meters.
Elevator: 0.72 square meter.
Vertical stabilizer: 0.56 square meter.
Rudder: 0.44 square meter.
Weight, empty: 700 kilograms.
Pilot: 86 kilograms.
Weight of fuel for flight of 10 minutes 46 seconds: 144 kilograms.
Total weight: 930 kilograms.
Load power per square meter: 84.5 kilograms.
Load power per horsepower: 2.9 kilograms.
Motor, Hispano-Suiza, 140 by 150, giving at 1,900: 320 horsepower.
Propeller diameter: 2.3 meters.
Pitch: 3 meters.
Radiators: Lamblin.
Oil coolers: Lamblin.
Fuselage: Monocoque.
Dihedral: 1.3°.

The wing is formed of two spruce spars, braced by compression tubes of steel in the lift truss terminating in the landing gear with crosstie pieces of steel. The surface is veneered and the entering edge of the wing is veneered.

This machine has attained a speed of 206 miles per hour and represents the fastest machine in the world to-day.

NIEUPORT TYPE XXXII SINGLE-SEATER SHIP PLANE.

This machine is specially designed for shipboard use. It is armed with two machine guns and can be utilized for marine pursuit and reconnaissance missions. It is practically the same as the Nieuport XXIX in outline and construction, as will be noticed from its outline

characteristics. Its low-loading and general flying characteristics tend to make it a very good interpretation of a shipboard pursuit and reconnaissance plane.

Characteristics:

- Length: 6.7 meters.
- Span: 9.7 meters.
- Area: 30 square meters.
- Motor: 180 horsepower Le Rhone.
- Weight, empty: 603 kilograms.
- Fuel weight: 174 kilograms.
- Useful load: 80 kilograms.
- Total weight: 857 kilograms.
- Flight endurance: 4½ hours.

Performance:

- Speed at ground: 193 kilometers per hour.
- Climb to 3,000 meters: 12 minutes 3 seconds.
- Climb to 5,000 meters: 24 minutes.
- Climb to 6,000 meters: 38 minutes 29 seconds.

It is unnecessary to describe the other Nieuport machines, as they are well known, and data concerning them is available in our technical files.

BREGUET AIRCRAFT.

SESQUIPLAN 19 A 2.

The Breguet plant is located at Villacoblay. The most notable new type under construction is the Breguet Sesquiplan 19 A 2, which is a military corps d'armée and grande reconnaissance type. This machine has been specially studied to combine characteristics of speed and climb with effective armament, modern wireless installation, heat for the pilot, lighting and photographic installations, to a degree that would make this airplane perfectly adapted to the requirements of a modern war.

General characteristics:

- (a) Sesquiplan with semithick wings.
- (b) Tractor propeller, 2-place dual control.
- (c) Motor, Renault: 450 horsepower.
- (d) Span, upper wing: 14.85 meters.
- (e) Span, lower wing: 9.54 meters.
- (f) Length: 9.2 meters.
- (g) Height: 3.3 meters.
- (h) Total surface: 45 square meters.
- (i) Chord: 1.9 meters.
- (j) Wheels: 800 by 150.
- (k) Gasoline: 450 liters.
- (l) Oil: 28 liters.
- (m) Weight, empty: 1,155 kilograms.

Military part.—

- (a) Military load totals 750 kilograms, made up of equipment, gasoline for four (4) hours full out at sea level, armament, wireless, heating arrangements, lighting and photographic installations.
- (b) Weight empty: 1,155 kilograms.
- (c) Load: 750 kilograms.
- (d) Total weight: 1,905 kilograms.
- (e) Rate of climb:
  - 1,000 meters: 2 minutes 45 seconds.
  - 2,000 meters: 5 minutes.
  - 3,000 meters: 7 minutes 45 seconds.
  - 4,000 meters: 11 minutes.
  - 5,000 meters: 15 minutes.
  - 6,000 meters: 22 minutes 30 seconds.
  - 7,000 meters: 40 minutes.

Military part—Continued.

- (f) Horizontal speed:
  - Ground: 230 kilometers.
  - 1,000 meters: 227 kilometers.
  - 2,000 meters: 224 kilometers.
  - 3,000 meters: 220 kilometers.
  - 4,000 meters: 215 kilometers.
  - 5,000 meters: 210 kilometers.
  - 6,000 meters: 204 kilometers.
  - 7,000 meters: 196 kilometers.
- (g) Absolute ceiling: 7,900 meters.
- (h) Service ceiling: 7,400 meters.

Description of installations.—(a) Electrical installation: The various supports, boxings, and fittings necessary to receive the electrical installation in detail are provided in this design as well as generator and storage battery installations. Provisions for wiring throughout the fuselage and wings, switches, boxes, fittings, and supports necessary for the wireless receiving and sending set, signaling outfit, heated clothing, cockpit lighting and lights are provided.

(b) Photographic accessories: The installation provides for a vertical photographic outfit of 0.50 to 1.20 meter focal length. For oblique photographic purposes, a 0.50 meter focal length. Installation of plate holders and fuselage floor sight glass is also made.

(c) Armament: (1) Installation for one (1) fixed synchronized Vickers or Darne machine gun in front cockpit.

(2) Synchronizing apparatus regulating fire of this machine gun.

(3) Bowden trigger control controlling fire of this fixed machine gun.

(4) Tourelle mount pivoted, 800 millimeters in diameter, capable of receiving two (2) Lewis or Darne machine guns, actuated by the observer or gunner in rear cockpit.

(5) Installation of a Chretien sight.

(6) Ammunition boxes for the fixed machine gun and magazine cartridge trays for the tourelle mount.

(d) Fuel system: (1) One A. M. sylphon gasoline pump, actuated by the motor, supplies the gasoline to the carburetor under constant pressure.

(2) One upper tank — 230 liters capacity — with Lanser protection rendering it inexplosible and noninflammable.

(3) Lower tank—220 liters capacity—which could be detached at will by the pilot.

(4) In the pilot's cockpit are the following instruments:

- One radiator water thermometer.
- One motor tachometer.
- One gasoline capacity gauge for each gas tank.
- One cockpit elevator control compensator.
- One cockpit rudder control compensator.
- One speed indicator.

General description.—This machine is of the single-bay, single-strut type, without wires in the plane of the lift truss, but with landing wires extending from the top longerons to the bottom wing at outer strut point. The fuselage is of the conventional Breguet type, duralumin tubing and steel fitting construction and with sides fared with crowning from top to bottom. The radiator is of the annular fin type, located just back of the propeller, the elements being quite similar to the famous Lamblin type. The landing gear is of the conventional Breguet type with wires extending from the rear of the landing gear to the bottom wing at the outer strut point to complete the rigidity of the wing cellule lift truss. The tail surfaces

are of the conventional Breguet type. Ailerons are fitted to the bottom of the top wing only. The propeller is fitted with a spinner.

Comments.—This machine is very interesting from a standpoint of cleanliness and design, coupled with the realization in a large degree of the requirements laid down by the French service for such a type. The Breguet type of metal construction, especially the fuselage, is such as to allow great accessibility. The visibility is quite good. The elevators and rudder are counterbalanced but the ailerons are not. This machine is one of the two best interpretations of metal construction that was seen in France. The Breguet engineers fully realize the great value of streamlining. They attribute much of the high speed and climb characteristics to streamlining.

BREGUET LEVIATHAN TRANSPORT, TYPE XXII, 900 HORSEPOWER.

This machine is motored with two 450-horsepower Breguet Bugatti motors. The motors are located between the wings and out from the fuselage. The characteristics of the machine are as follows:

(a) Span: 25.5 meters.
(b) Length: 14 meters.
(c) Height: 5 meters.
(d) Total surface: 140 square meters.
(e) Weight, empty: 3,000 kilograms.
(f) Useful load: 3,500 kilograms.
(g) Weight per square meter: 40 kilograms.
(h) Weight per horsepower: 7 kilograms.

This machine has been especially studied for commercial purposes, although it could be changed into a military model, if necessary.

Nature of load for a radius of 600 kilometers:

(a) Two pilots: 150 kilograms.
(b) Wireless: 100 kilograms.
(c) Gasoline, 940 liters: 675 kilograms.
(d) Oil, 83 liters: 75 kilograms.
(e) Twenty-five passengers with baggage: 2.500 kilograms.
(f) Total useful load: 3,500 kilograms.
(g) Total weight of machine loaded: 6,500 kilograms.
(h) Speed at 2.000 meters: 170 kilometers.
(i) Endurance of flight: 3½ hours.
(j) Service ceiling: 4,000 meters.

Nature of load for a radius of action of 1,100 kilometers:

(a) Two men: 150 kilograms.
(b) Instruments and radio: 100 kilograms.
(c) Gasoline: 180 kilograms.
(d) Oil: 120 kilograms.
(e) Twenty passengers and baggage: 2,050 kilograms.

The pilot is placed immediately behind the main passenger cabin. He has excellent visibility for all flight conditions and also can see the ground for landing purposes. In close proximity to the pilot is an aide pilot-navigator, who also operates the wireless, which is installed in the cabin in immediate proximity. Doors permit the passage from the pilot's cockpit to the passenger's cabin or to the radio cabin.

Arrangement of cabin.—A door placed in the front of the fuselage permits ease of mounting into the passenger's cabin. A stepladder is carried on board for mounting and dismounting. The cabin is about 7 feet high and spacious and comfortable. The visibility is excellent and the ventilation of the cabin is automatically regulated to any degree for the passengers' comfort. A passage running to the rear of this cabin permits the passengers to have access to a lavatory. Space is provided for the passengers' hand baggage.

Power plant.—The motors are two groups of Breguet Bugatti bimotor 450 horsepower.

Summary.—The construction of the wings and fuselage is entirely of duralumin. Their construction is too complicated to adopt for military or commercial craft. This machine represents an experiment in the fine art of handling duralumin for aircraft construction. The rings are very light in weight (about 1 pound per square foot) and the construction emphasizes the comparative advantages of metal construction over wood where weight is concerned. This construction would be impossible in production.

The machine had never been flown to date and at the time we were in Paris the first machine was being sand tested. The machine is very conventional in outline, of the twin-motored central fuselage type, with the wide track landing near with double wheels. Each wheel is 52 inches in diameter, equipped with the latest Palmer flat-tread tires.

BREGUET COMMERCIAL SINGLE MOTOR TRANSPORT MACHINE.

This machine is powered with a 300 horsepower Renault and is practically the same as the Breguet ambulance airplane (described below). The stretcher equipment has been removed and comfortable seats provided for the passengers. Further data and photographs of these machines were procured and will be found in our files.

SUPERCHARGERS, OBSERVATION, AND CORPS D'ARMÉE.

Breguet is also delivering a quantity of duralumin all-metal tubing jobs for high-altitude observation work. They have a 450-horsepower Renault with a Rateau supercharger. The air cooling for the supercharger is taken care of by two air radiators on the side of the fuselage. Lamblin radiators are used for water cooling. The Breguet Co. have tried metal covering on some of their experimental ships and have used a system which is quite novel. Sheets are rolled very thin and are cut into strips about 1½ inches wide. Both edges of the strips are bent back and the strips are riveted together by fastening these flanges. The smooth side of the covering is external and although it is a very nice job to look at, it is not very practical on account of the number of labor hours required and the fact that the covering is so thin that the vibration would crack it. Some pontoons in the factory have been built up in the same way, but were found to be unsatisfactory. Breguet type duralumin tubing and steel fitting fuselage construction is most interesting from the standpoint of practicability, and of structure with low-weight and high-strength factors.

BREGUET TYPE XIV.—DAY BOMBARDMENT.

This machine has been very fully described in data which we have in our technical section and is of the conventional Breguet type construction throughout.

One of the interesting features of the night bombardment type is the arrangement of the bomb-sight apparatus

situated on the right side of the observer's cockpit. A hole is cut in the fuselage fabric covering midway between the top and bottom longerons on the right side of the gunner observer's cockpit. A blinker or air deflector is located ahead of this hole so as to deflect the slipstream which would otherwise interfere with sighting. The bomber sits near the bottom of the fuselage and sticks his head out through this hole to do his sighting. The bomb sight is immediately back of this blinker door and protected from the slipstream. The door is operated at will, usually, by the bomber. The vision is good and accuracy has been attained by this method. The seat for the bomber must be provided in two locations. One permits his operating the dual control or going along in regular flight in observation work and the other permits him to bomb or take pictures.

BREGUET AMBULANCE PLANE—XIV T.

This machine is one of the standard Breguet types, powered with the 300-horsepower Renault, designed to carry two patients, one above the other and ahead of the pilot, who occupies the position that the gunner or observer does in the ordinary military types.

It is a very interesting adaptation of a military machine for ambulance purposes and at best represents more or less of a makeshift of their regular jobs to suit the purpose.

On the right side of this machine is a door permitting the attendant to accompany the two patients and sit alongside of them. A cabinet placed in immediate proximity contains a complete first-aid equipment and different-sized syringes, thermos bottles, morphine, caffeine, ether, sparteino, camphor oil, serum, scissors, nickel-plated cleaning utensils, bandages, disinfectants, etc. A small table permits the disposition of this material by the physician accompanying the patients to soothe the immediate needs of the injured. A complete electrical installation permits lighting the compartment and heating the blankets in the patients' litters. This energy is furnished by a propeller-driven generator.

A French service report is filed in our technical data files showing the service to which these Breguet ambulance jobs have been placed in Morocco in 1921. It is convincing evidence of the importance of ambulance jobs for field work in dangerous first-aid cases demanding immediate, skilled medical attention.

BREGUET SHORT DISTANCE NIGHT BOMBARDMENT, TYPE XVI.

Characteristics:
- (a) Biplane, tractor, dual control.
- (b) Motor, Renault: 450 horsepower.
- (c) Span, upper wing: 17 meters.
- (d) Span, lower wing: 17 meters.
- (e) Ailerons counterbalanced.
- (f) Total length: 9.55 meters.
- (g) Height: 3.32 meters.
- (h) Total surface: 73 square meters.
- (i) Gasoline capacity: 430 liters.
- (j) Flight endurance: 5½ hours.
- (k) Total weight: 2,450 kilograms.

PERFORMANCE WITH 300-HORSEPOWER RENAULT.

- (a) Military load: 1,130 kilograms, of which 550 kilograms were bombs.
- (b) Climb:
  - 1,000 meters: 10 minutes 35 seconds.
  - 2,000 meters: 21 minutes 54 seconds.
  - 3,000 meters: 37 minutes 43 seconds.
  - 3,500 meters: 51 minutes 10 seconds.
- (c) Ceiling: 4,600 meters.
- (d) Maximum speed, ground: 160 kilometers per hour.
  - Maximum speed, 2,000 meters: 150 kilometers per hour.
  - Maximum speed, 3,000 meters: 139 kilometers per hour.
  - Maximum speed, 4,000 meters: 138 kilometers per hour.

This machine is equipped with two Michelin bomb racks, located underneath the wings, which permits various combinations up to a load of 550 kilograms. Total weight in bombs of different sizes as follows:

Number of bombs.	Weight of each.	Diameter.	Total weight.
	Kilograms.	*Millimeters.*	*Kilograms.*
32	10	90	320
32 (incendiary)	10	120	320
16	25	155	400
8	50	200	400
5	100	275	500
2	200	380	600
2	100	275	

The bomb-rack fittings are so designed as to carry two bomb flares of the Michelin type, weighing about 11 kilograms each. The bomb-dropping control mechanism is of the Michelin type. The gasoline system of the A. M. Sylphon pump type, motor-driven. The gasoline tank is of 430 liters capacity in two compartments with Lanser protection.

Summary.—This machine has been built with different engine installations. A Liberty motor has been used. This is a machine of unique characteristics with a reliable power plant, capable of carrying a large load. It is the best performance that has been obtained with a 300 Renault. Its characteristics are such that the French air service has placed large orders for it in the past and have many on order at present.

BREGUET TWO-SEATER FIGHTER, TYPE XVII.

Characteristics:
- (a) Biplane, tractor, 2-place, dual control.
- (b) Motor, Renault: 450 horsepower.
- (c) Span, upper wing: 14.200 meters.
- (d) Span, lower wing: 12.560 meters.
- (e) Upper ailerons only counterbalanced.
- (f) Height: 3.460 meters.
- (g) Length: 8.1 meters.
- (h) Area: 45.3 square meters.
- (i) Gasoline: 450 liters.
- (j) Endurance: 4½ hours.
- (k) Total weight: 1,840 kilograms.

Performance.—The following performances have been officially obtained with a military load of 625 kilograms.

(a) Climb:

2,000 meters: 5 minutes 45 seconds.
3,000 meters: 9 minutes 30 seconds.
4,000 meters: 14 minutes.
5,000 meters: 20 minutes 41 seconds.
6,000 meters: 31 minutes.

(b) Ceiling: 7,500 meters.

(c) Maximum horizontal speed:

Ground: 221 kilometers per hour.
2,000 meters: 218 kilometers per hour.
3,000 meters: 213 kilometers per hour.
4,000 meters: 207 kilometers per hour.
5,000 meters: 199 kilometers per hour.
6,000 meters: 186 kilometers per hour.

Armament.—The armament installation consists of two fixed Vickers machine guns, synchronized, one Aldis sight, two tourelle mounted Lewis machine guns, and provision for one floor gun if necessary. This machine is of a well-known type and of the conventional Breguet type of construction. It is very similar to the Breguet machines that we have on hand in this country.

Provision is made for electrical installation, oxygen installation, water thermometer, tachometer and speed indicators.

The gasoline system is of the A. M. Sylphon motor-driven type. The upper gasoline tank, Lanser protected, is of 230 liters capacity, and the lower tank of 220 liters capacity is detachable.

POTEZ MACHINES.

The Potez Co. is doing considerable work with metal construction and have designed and built two types of machines to French military specifications as well as several machines for commercial work.

Their two-place observation and night pursuit machine has the following characteristics:

Span: 12 meters.
Length: 8.40 meters.
Area: 45 square meters.
Motor: Lorraine, 370 horsepower.
Weight, empty: 1,100 kilograms.
Fuel: 255 kilograms.
Military load: 400 kilograms.
Total weight: 1,725 kilograms.
Loading per square meter: 39 kilograms.
Loading per horsepower: 4½ kilograms.
Speed at ground: 210 kilometers per hour.
Speed at 3,000 meters: 195 kilometers per hour.
Speed at 5,000 meters: 180 kilometers per hour.
Climb to 1,000 meters: 3 minutes 30 seconds.
Climb to 3,000 meters: 13 minutes.
Climb to 5,000 meters: 29 minutes.
Ceiling: 6,200 meters.

This machine has been designed to fulfill French type requirements for observation and night pursuit. This machine is representative of conventional type in design and is featured with Lamblin radiator installation. It is apparently a good all-round, strong machine with no particular features of construction, and the type is very closely analagous in seating arrangement and general layout to our DH-4B.

The Potez Co. is now experimenting and building up this machine of duralumin shapes. The fuselage longerons are being made of duralumin angles with gusset plate strut longeron joints, braced transversely by means of duralumin gussets only, and fore and aft with wires.

Their new duralumin wing construction is quire simple. It is a new interpretation of metal construction, being entirely built up of duralumin channels, angles, and gusset plates throughout. It is very easy to manufacture. It will be interesting to watch the development of this machine in metal.

Another interesting ship is the three-motored colonial type, designed to carry 10 or 12 passengers. This machine has folding back wings. It has a total wing area of 94 square meters and a weight of 3,500 kilograms. The wings, longerons, ribs, etc., are entirely of duralumin. The longerons in this job are of a T profile section, made from two pieces riveted together. The wire gusset fittings entirely envelop the longeron and in this manner detract from the fatigue and strain that would be the case with wire attachment bolts directly piercing longerons. The ribs are built up of U sections with trelliswork type truss. These ribs have withstood a static test of 10 load factors.

The landing gears are very unique, made up of three separate twin-wheeled chassis. Each one of these chassis has two rear legs working in telescopic fashion. The compression induced in the telescopic action is resisted by a shock absorber made of rubber washers. These washers are absolutely distinct and separated from one another by metal washers so as to prevent fraying between them. This landing gear has withstood a load of 15,000 kilograms without any permanent deformation. The striking advantage of using these rubber washers is the fact that the shock-absorbing medium is absolutely separate and apart throughout the telescopic barrel. Thus it does away with a possibility of serious damage to the machine due to the breakdown of the shock absorbers, such as occur with present types. These shock-absorbing legs can be very readily replaced in the field. The exterior is clean, easy to streamline, and allows the axle and the wheels to be mounted in a unit.

Another unique feature of the Potez three-motor job is the adjustable vertical tail surface and horizontal surface. There are three vertical fins, one fixed and two movable. The two movable fins are counterbalanced single surface and actuated by a cockpit handwheel with a worm-actuating mechanism. Apart from the fixed stabilizer is a movable, counterbalanced stabilizer which is likewise operated and controlled for variance of incidence from the cockpit.

This machine is well thought out and is a good interpretation of the specifications for this type.

The other machines manufactured by Mr. Potez are mostly of a commercial type and are of no special interest from an air service viewpoint.

WIBAULT MACHINES.

The Wibault Co., headed by Mr. Wibault, has made a great contribution to France and to aeronautics by their new all-metal bomber. The machine is bold in design and thorough in detail, embodying most of the French requirements.

The machine, known as the Wibault B. N. 2, is an all-metal biplane for night bombardment. It is powered with a Renault 600-horsepower motor and has the following characteristics:

- Length, over all: 41 feet 10 inches.
- Span: 55 feet 6 inches.
- Height: 16 feet 5 inches.
- Wing area: 1,035 square feet.
- Engine: 600 horsepower Renault.
- Weight, empty, but with cooling water: 4,620 pounds.
- Useful load: 3,100 pounds.
- Fuel for four hours at 6,500 feet; 160 gallons.
- Total loaded weight: 9,450 pounds.
- Speed at 6,5 0 feet: 125 miles per hour.
- Wing loading 9.1 pounds per square foot.
- Power loading: 15.8 pounds per horsepower.

This machine is the most interesting type of all-metal construction that was seen in France with the exception of the Breguet Sesquiplan. One of the striking features of this machine is the location of its bomb and gas loads, which are entirely disposed within the fuselage of the machine. This affords a streamlined outline for the ship, irrespective of the nature or kind of load carried and does not detract from the ultimate performance by added resistance of external bomb installations such as is found in the majority of military machines.

The wing truss is of the single-bay type. The top wing is shorter than the bottom wing. The reason for this, according to Mr. Wibault, is the structural advantage in the saving of weight, due in this case to the higher structural resistance to the compressive axial ends loads induced under maximum stress conditions in the upper wing. It also permits ease of alignment in the field and reduces parasite resistance to a minimum. The wing ribs are built up of duralumin tubes in trellis structure fastening with duralumin gusset plate joints. This makes a very rigid rib without any weak joints. It represented the very safest type of built-up rib that was found in Europe.

The spars are built of duralumin. The face webs are the flange type with lightening holes, produced by bending at right angles along straight lines and by supplying a radius near the flange that supports the flanged edges. This construction is advantageous inasmuch as the flanges can be made without the expense of costly dies for stamping. The spar flanges themselves are flat strips of duralumin riveted to the flanged edges of the webs.

The wings have withstood a load factor of seven and a half without showing any permanent deflection, and to all appearances the detail wing construction was in very good condition.

The fuselage is of the Breguet type of duralumin tubing and steel fitting construction. The tail planes are built up similarly to the wings. The pilot and gunner are situated far back in the fuselage. In fact they are halfway from the trailing edge of the wings to the sternpost. The vision aft and overhead in this case is very good, but the vision forward is quite questionable and is receiving criticism. The crew is well protected in case of a crash and this machine fulfills its night bombardment mission very well. This arrangement has been carried out with the idea of locating the fuel and bomb load as near to the center of gravity of the machine as possible so that the variation in useful load will require very little time and attention of the pilot to the tail adjustments.

The landing gear is of the conventional twin V rubber shock-absorbing type. The machine uses Lamblin radiators, one of which is mounted on either side of the fuselage near the engine.

Mr. Wibault is working on a pursuit machine of the Hispano 300-horsepower motor. It will be all-metal with the general structural characteristics of the bomber. However, it will be semi-internally braced with struts projecting from the bottom of the fuselage to halfway out on the wings.

The performance is theoretical and claimed by the Wibault Co., but their high estimate is probably very optimistic.

Characteristics:

- Motor, Hispano: 300 horsepower.
- Rateau supercharger.
- Span: 11.400 meters.
- Length: 8.50 meters.
- Useful load: 450 kilograms.
- Speed at 3,000 meters: 300 kilometers per hour.
- Ceiling: 12,000 meters.

MORANE SAULNIER.

The Morane Saulnier Co. has been engaged in wing experimentation on their regular type A. R. 80 horsepower Le Rhone parasol monoplace. They have changed their old conventional thin wing to an internally braced thick wing. This change has been made simply with the idea of study and to get full-scale data on the relative advantages and disadvantages of this new thick wing over that of the preceding thin wings. This wing is braced practically Fokker fashion.

The characteristics of the machine with this new wing are as follows:

- Span: 8.90 meters.
- Surface: 13 square meters.
- Load empty: 545 kilograms.
- Useful load: 140 kilograms.

The object of this test has been to obtain a suitable wing for their two-place Corps d'Armée.

The most important development work being done by this company is their three-motored monoplane. It is the internally braced type of tapered wing with two of the engines located in the leading edge of the wing. It is all-metal construction. Full description of this plane is given in this report under the heading "Résumé of French research, development, and service aircraft" on pages 7, 8, and 9.

Basic characteristics of this machine are as follows:

- Span: 93 feet.
- Length over all: 56 feet 8 inches.
- Height: 10 feet 5 inches.
- Chord maximum: 19 feet.
- Area: 1,300 square feet.
- Engines: 1,200 horsepower.
- Weight, empty: 9,500 pounds.
- Weight, loaded: 15,500 pounds.
- Estimated high speed: 150 miles per hour.
- Estimated ceiling: 15,000 feet.

FARMAN AIRCRAFT.

Farman has continued to use the old, conventional type of stick and wire construction, but has developed some efficient weight carriers. He has, however, built considerably in metal also.

THE FOUR-MOTORED 1,500-HORSEPOWER FARMAN.

The latest addition to the Farman group of ships resembles closely and shows a marked influence of the famous Farman Goliath. It is powered with four Lorraine-Dietrich engines, the power eggs being situated on the lower wing at the first strut station, directly over the landing gears. Each power group has two motors in tandem. The fuselage carries an auxiliary landing gear attached to the front to prevent nosing over. The mechanics can go out to the motors and attend to any light repairs or make adjustments necessary to their functioning in flight. It is also provided with a wireless cabin.

This immense machine has a—

Span: 34.50 meters.
Total length: 22 meters.
Total height: 7.50 meters.
Chord: 4.65 meters.
Gap: 4.65 meters.
Total surface: 300 square meters.
Weight, empty: 6,000 kilograms.
Useful load: 4,500 kilograms.
Total weight: 10,500 kilograms.
Speed at sea level: 160 kilometers per hour.
Ceiling: 4,500 meters.

Owing to the difficulty of packing and shipping these enormous wings, the trailing edges are removable. This machine is now at Orly undergoing assembly for preliminary tests.

FARMAN GOLIATH.

Fifty Goliath type bombers are being built for the French Government. They are motored with two 235-horsepower Salmson motors in nacelles mounted on the bottom wing. They carry approximately 1 ton of bombs and seven hours' gas. However, Mr. Farman would prefer the machine with motors of the 270-horsepower, Renault type, due to the fact that a lot of trouble has been experienced with the Salmson engines. These bombers have been designed to fulfill night bombardment specifications and the characteristics of this machine in toto will be found in our files.

Thirty-five of the Farman Goliath type have been constructed for transport work and are about completed.

One of this type of ship has been built and remodeled to be used as a flying laboratory. The rear compartment contains a finder which is nothing more nor less than the usual insulated loop on the pivoted frame. Next is the radio operator's cabin, which is equipped to allow the operator to sit comfortably and have easy access to two tables on which instruments would be mounted. The cabin is almost soundproof and is shut off by a door from the rest of the ship. The radio sets have a radius of action of 300 kilometers with the telephone sets and 500 kilometers with the telegraph sets. A passage leads from the pilot to the navigator's cabin, which is provided with plenty of space to work and keep charts. The navigator can go out of his cabin and take sight with a compass.

In front of the radio cabin is the pilot's post. The pilot is on a raised platform on the left side of the machine and has a fair vision. There is no dual control. The machine is being used to try automatic stabilization on the lateral controls. The wheel is provided with a straight tube grip which is superimposed from the base of the wheel to allow control of the elevator surface without interference with the lateral controls.

A very excellent magnetic compass is placed in front of the pilot, but as the wheel is sometimes apt to obstruct his vision, the compass is provided with a prism which enables him to see it at all times. The compass is illuminated in the usual way. The compass is so equipped with a prism and a light that the navigator sees his sighting point and the compass reading at the same time. The compass is mounted on a slide so as to allow it to be lowered and pulled within the adjustable top of the compartment.

Another interesting instrument is mounted in the pilot's cockpit but was not seen in the machines at the factory. It is merely an adaptation of the disk system of communication between navigator and pilot. Two disks which are identical are provided with hands which can be moved by either pilot or navigator and about 25 form messages can be sent. A wire runs over two small pulleys which are fixed to the hands and actuates them. The installation is very good, but it could be improved by the addition of enough spaces to allow words to be spelled out. The instruments could be provided with a tape to record automatically the message sent. This presents no difficulty and would be a good auxiliary means of communication. The real way to communicate between pilot and navigator is by word of mouth.

A slightly different type of flight indicator and inclinometer is also provided. It consists of the usual gyro mounted vertically and provided with a small mirror mounted on top. A source of light beam is provided by a small electric bulb. The mirror reflects the beam on a translucent dial, which is fixed on an adjustable base mounted directly on the plane so that the beam shows whether the machine is flying level, climbing, or drooping a wing. It should show whether the machine is turning, and possibly it does, but centrifugal force may commence to act on the gyro and the usual precession take place, which may or may not interfere with the accuracy of the reading. The instrument will allow the pilot to climb the ship at the best possible climbing angle and glide at the flattest glide. In its present interpretation, the instrument is not very remarkable except for being a different application of old and well-established principles. They might be infused into one instrument, which in fact could be made a turn indicator, flight indicator, inclinometer, gradometer, airspeed meter, and a device to show best glide and climb.

The navigator is also provided with a turn indicator or derivimeter S. T. Aé. and bomb sight in one. It is the old principle of a hole in the floor provided with a series of adjustable parallel lines in such a way as to allow objects to move along these lines and then read the angle. By means of a sight graduated for altitude, it is possible to read the ground speed by applying the time coefficient to the graphic chart provided. Windows in the side of the navigation cabin give ample lateral visibility.

FARMAN TWO-PLACE OBSERVATION TYPE A-2.

Farman is at present constructing 100 of these machines which are built of duralumin shapes and powered with the 260-horsepower Z 9 type Salmson engines. The job is a dual control with a deep, roomy cockpit for the observer. It is a conventional two-bay machine and from outside appearances does not seem to be especially novel, but the performance is reported to be especially satisfactory. It carries three hours' fuel and oil.

Characteristics:

Span: 12 meters.
Area: 37 square meters.
Weight, empty: 895 kilograms.
Weight, full load: 1,420 kilograms.
Load factor imposed in static tests: 8 plus.

The flight tests conducted by the French technical section with a load of 525 kilograms gave the following results:

Ground speed: 191 kilometers per hour.
Speed at 5,000 meters: 175 kilometers per hour.
Ceiling: 6,600 meters.
Climb to 2,000 meters: 7minutes 30 seconds.
Climb to 3,000 meters: 12 minutes 35 seconds.
Climb to 5,000 meters: 28 minutes 35 seconds.

The weight of this machine is remarkably light when one considers the weight empty and the heavy useful load that it carries per horsepower.

FARMAN TORPEDO PLANE.

The Farman torpedo plane is a two-place biplane with the bottom of the fuselage hollowed out to receive a torpedo. It is powered with the 450-horsepower Renault. It is entirely constructed of wood.

Characteristics:

Span: 18 meters.
Length: 13 meters.
Area: 100 square meters.
Weight: 3,200 kilograms.

This machine is not capable of landing at sea, but has a landing gear quite similar to the Farman Goliath. The fuselage is divided up, however, into water-tight compartments so it would float in case of forced landings at sea. It has a conventional two-bay wired wing truss and all control surfaces are counterbalanced.

HANRIOT.

The Hanriot Co. has designed and constructed at large the following well recognized and known types:

Type HD-1. Single-place acrobatic pursuit.

Type H. Powered with the 120 Le Rhone engine.

Type HD-2. Single-seater seaplane pursuit; powered with the 130 Clerget.

Type HD-3. Two-place pursuit; powered with the 240-horsepower Salmson engine.

Type HD-6. Combat; two-place; powered with the 500-horsepower Salmson engine.

Type HD-7. Single-place; high altitude; pursuit; with the 300-horsepower Hispano.

Type HD-9. Corps d'Armée reconnaissance for long distance; single-place; powered with 240-horsepower Salmson.

Type HD-12. Single-place pursuit.

TYPE HD-12. SINGLE PLACE-PURSUIT.

The HD-12 is of the conventional Hanriot stick and wire construction with characteristics as follows:

Span: 9.60 meters.
Length: 6.15 meters.
Height: 2.50 meters.
Area: 25 square meters.
Motor, Le Rhone: 180 horsepower.
Weight, empty: 470 kilograms.
Maximum speed: 190 kilometers per hour.
Speed at 3,000 meters: 187 kilometers per hour.
Climb to 1,000 meters: 2 minutes 39 seconds.
Climb to 3,000 meters: 9 minutes 14 seconds.
Absolute ceiling: 7,250 meters.
Service ceiling: 6,750 meters.
Endurance: 2 hours.
Useful load: 150 kilograms.
Load factor: 7.

This machine has been specially designed for taking off from ships' decks and is very well adapted for this type of work, as was evidenced in flights from the deck of the *Berne* at San Raphael. Pilots like the machine very well for this kind of work. Although the maximum speed is not great, still it has very good qualities of maneuverability and climb, a low landing speed, and quick takeoff, which give it the essential qualities for shipboard use. The visibility is very good. The performances are equivalent to those obtained in the famous HD-1.

TYPE HD-14 TWO-PLACE TANDEM TRAINING MACHINE.

This machine has been a special study to permit the rapid instruction of pupils with the minimum risk to the pilots. It is a biplane equipped with the 80-horsepower Le Rhone engine. The construction is of the Hanriot stick and wire. It is very simple and permits easy and rapid replacement of any of the important elements.

This machine was designed especially for training purposes on an average airdrome. Its physical characteristics are a wide track landing gear formed by a double-skid twin chassis with independent vees. This construction tends to minimize accidents in getting off and in landing on rough grounds. This machine was tried out by the French technical section at Villacoublay. It gave results which classified it as one of the most effective types of training machines in France.

This machine featured a Hanriot dual mechanism of the quick-release type which allows the pilot to disorganize the student's control while in flight by a simple cam action.

The principal characteristics are as follows:

Span: 10.40 meters.
Area: 34.5 square meters.
Total length: 7.25 meters.
Weight, empty: 529 kilograms.
Weight of fuel: 84 kilograms.
Useful load: 170 kilograms.

Performances realized are as follows:

Maximum speed at ground: 120 kilometers per hour.
Minimum speed in flight: 70 kilometers per hour.
Climb to 1,000 meters: 6 minutes.
Climb to 3,000 meters: 30 minutes.
Ceiling: 4,700 meters.

The Hanriot Co. is engaged in turning out 75 of these machines for the French Government, as well as many for foreign Governments.

HANRIOT TYPE 14 BIS.

This machine is practically the same as the HD-14 with the exception of its power plant equipment. It has a Clerget 130-horsepower motor and a more simple, conventional type landing gear. These changes were made to cut down head resistance and in order to obtain a more advanced training machine with great speed and better performance. It is really only a machine for more advanced training than could be given with the 80-horsepower Le Rhone motored HD-14 type.

HANRIOT TYPE HD-17 TWIN FLOAT NAVY TRAINING MACHINE.

This machine is practically the same as the HD-14 except for the adaptation of twin floats which are attached to the same points as the landing gear and the adaptation of a 130-horsepower Clerget motor in place of the 80-horsepower Le Rhone. This machine has a balanced twin-float system and a small tail float in place of the tail skid. The general characteristics are the same as the HD-14 training job. The weight, in order of flight, is about 1,000 kilograms. The weight, empty, is 740 kilograms. The maximum speed at sea level is 120 kilometers per hour. Its ceiling is 4,000 meters. Qualities of flight and maneuverability are quite identical with the conventional HD-14 type.

HANRIOT STUDENT DISENGAGING DUAL CONTROL.

The Hanriot student disengaging dual control from the pilot's cockpit is the best interpretation of the type that has been developed to date and a type similar to it, or functioning equally as well, ought to be installed on all our training types. An assembly drawing is available showing principles of installation and operation.

HANRIOT METAL CONSTRUCTION.

While still devoting their productive efforts to the construction of stick and wire machines, the Hanriot Co. has fully realized that the era of metal is at hand and are doing some experimental work along metal construction lines.

This metallic construction is evidenced in one case by a two-seater 300 Hispano motored, supercharged, high-altitude, pursuit airplane of steel tubing. This machine is at present in the experimental state and has not been flown to date. It is a first step, and we may well expect progress.

Hanriot machines have always been well built and practicable. This has followed through their long line of conventional models. Now that their engineering division has gone into metal, it is not too much to expect them to turn out a first-class, all-metal machine in the near future.

DURALUMIN.

France realizes fully the value of duralumin for the manufacture of aircraft. She has encouraged the development of the industry in every way possible and at the present time is able to secure an adequate supply of this metal. In order to take advantage of the facilities of the French air force technical section and to be near the center of aircraft development, the Society Duralumin have located one of their plants on the outskirts of Paris which devotes its entire energy to the manufacture of duralumin for aeronautical construction.

This plant was inspected. A great amount of development and experimental work has been done, but every operation is now reduced to a production basis. Facilities are available for conducting every necessary test to determine whether the finished product meets specifications. The plant has a competent force of skilled workmen that would form the nucleus of a great plant should quick expansion become necessary.

The metal is prepared in the usual way and run into tubular molds. From outward appearances there is nothing unusual about the molds. They are clay-lined and vary in size with the size of stock desired. The stock is removed from the molds and the rough ends sawed off. This is done with an ordinary bandsaw. The pieces are then cut into lengths of about 18 inches.

The lengths are pierced by driving a hole through them with a pressure press. The press used for this purpose is a 500-ton press. After the length is pierced it is placed in another press of double the power and the length is forced out of the press in tubular shape. The processes are very rapid and simple.

The tubes are then handled in lengths of 15 feet. Cranes are used for conveying them. About 20 or 30 tubes are heat-treated at once and then plunged in a bath. This process is one that requires very exacting control of temperature, for a change of 15° in the bath will give the metal essentially different characteristics and it will not come up to the test requirements.

After being heat-treated the tubes are sawed off angularly at one end to allow for the jaw of a special machine that is used either to make the tubes perfectly round or any shape that is desired. The tube is pulled through a die that shapes it so that it is ready to be used as a spar or longeron without further process. The tubes then go to the inspection room, where they are carefully scraped and examined for flaws and are given specification check.

Samples of all the various shapes and sizes were procured and have been forwarded to the Chief, Air Service Engineering Division, Dayton, Ohio.

FRENCH MOTORS.

Motors are classified for consideration of their characteristics from a technical viewpoint by taking into account the system of cooling, whether air or water cooled, the disposition of the cyclinders, their location, volumetric efficiency or compression, motor regulation, and speed of rotation.

Lightness is a characteristic requirement for all aircraft motors. The latest representative French air-cooled job is the Le Rhone 180 horsepower rotary engine. To date they have failed to develop radial air-cooled motors of high horsepower. For motors of about 300 horsepower, the most efficient French engine from the consideration of weight in pounds per horse power, consumption per horsepower, cooling surface resistence per horse power and for high-altitude work, is still the 300 Hispano-Suiza.

The French Rateau superchargers are in service and are being further developed for pursuit and bombardment planes. The French adaptation of Rateau superchargers has been made and is being carried on experimentally with the French 300-horsepower Hispano-Suiza and Renaults of the 350, 450, and 600 horsepower types. The Rateau supercharger has been very well developed and physical evidences of plane installation is illustrated in the French Nieuport 29, the single-motored Breguet day

bombardment type with Renault engine, and the Spad two-seater observation plane.

The lower horsepower French motors are made up of types from 60 to approximately 330 horsepower, and practically all have direct drives. These are found in the majority of military types and are: The Renault 300 horsepower, Salmson 260 horsepower, Le Rhone 270 horsepower, Le Rhone 120 horsepower, Le Rhone 180 horsepower, Clerget 130 horsepower, Hispano-Suiza 150 horsepower, Hispano-Suiza 180 horsepower, Hispano-Suiza 200 horsepower, Hispano-Suiza 220 horsepower, and Hispano 300 horsepower. Motors of 400 horsepower and over run at speeds of about 1,300 to 1,600 revolution per minutes. The principal of these are the Renault 450 horsepower, Renault 600 horsepower, Lorraine Dietrich 400 horsepower, and Salmson 350 horsepower. These types are practically developed for field service.

French motors with reduction gears are rare and the only one that has been very much in evidence is the 220 horsepower Hispano-Suiza, which has never been very successful. The Lorraine-Dietrich 1,000 horsepower engine is still in the process of development. The only installations for the 160 and 180 horsepower rotary Le Rhone were in the Hanriot and Nieuport experimental pursuit types.

French opinion has not crystallized as to what the most desirable types of motors will be. Experimental work is still being done on the semi-Diesel and internal combustion types. It is evident from their practice to date that, in spite of the interest in aeronautical circles in obtaining a motor with fuel which is less inflammable than gasoline and their desire to reduce the fire hazards, gasoline engines still prevail. Trials with alcohol have shown that with a compression ratio of about 6, the same thermodynamic efficiency can be obtained as with gasoline, but the consumption is much greater.

With the advent of motors of increased horsepower, the question of light construction must receive serious consideration. From a weight per horsepower standpoint, the difficulties with air-cooled motors will likely be more assertive in weight horsepower ratio beyond the 400-horsepower type. Difficulty will be experienced in decreasing the resistence of the greater horsepower motors. The logical type to develop in water-cooled motors is one weighing 2 pounds per horsepower and producing 450 horsepower of the V type, capable of an endurance of a couple hundred hours. This is the type the French are trying to develop at present.

The short life of motors between overhaul is one of the disadvantages incidental to all the various water-cooled engines which the French hope to offset in a large measure. To realize this, they have instituted a motor competition for the design and development of a 450 horsepower engine that will have a life of 240 hours. They are offering a prize of 2,000,000 francs for the best motor designed embodying these characteristics. When this type has been perfected, it can be easily adapted to their pursuit and bombardment types, either with or without superchargers.

The characteristics of the Renault 600-horsepower engine are as follows:

Cylinders: 12. Bore and stroke: 160 by 180.
Cylinder displacement: 43. Leaders: 410.
Compression ratio: 5.3.
Power: 575 horsepower at 1,600 revolution per minute.
Total weight: 560 kilograms.
Consumption per horsepower:
  Gasoline, 260 grams.
  Oil, 25 grams.
Ignition: 2 magnetos, double ignition.
Carburetors: 2 Zenith doubles, Model 75 D 1.
Controls built into motor.
Cylinders separate, with steel water jackets.
Pistons: Aluminum.
Water pumps: Centrifugal type, two outlets.
Carburetor and spark control countershafts and rods are directly fixed to engine as part of assembly.
Four oil pumps.

Ten of these models have been delivered to the French Government and orders have been placed for 100 more. The first installation evidence of this motor has been in the Wibault night bomber. The 450 and 300 horsepower types are well known and do not require any description in this report. They are much in evidence in airplane installations of the Breguet types.

The Wright and Curtiss engines represent better pursuit engines than any the French have developed to date, from a standpoint of weight per horsepower, radiator surface required, and performance attainable. The Liberty motor surpasses in reliability, weight, and power ratio any of the French analogous types.

The progress in motor development in France has been retarded to a certain extent by the mass of war-time motors which are still on hand. A table follows, showing all French motors, giving the number available, their horsepower, weight, and the class of planes in which they can be used. By weight in the table is meant the radiator, water, oil, motor base, silencer, propeller, etc. The word "cannon" means a motor with a cannon shooting through the crank shaft. In referring to the plane in which the motor can be utilized, reference is made by using the French type specification identification, which is as follows:

- Pursuit:
  - Monoplace pursuit for high altitudes, C.1.
  - Monoplace pursuit for low altitudes, c.1.
- Pursuit and reconnaissance:
  - Biplace pursuit or reconnaissance, C.Ap.2.
  - Biplace pursuit and night reconnaissance, A.An.2.
- Observation:
  - Biplace, C. A., and divisional, A.2.
  - Biplace, C. A., and divisional, Ad.2.
  - Armored biplace for divisional squadrons, Ab.2.
- Bombardment:
  - Biplace, day bombardment, long distance, Bp.2.
  - Biplace bombardment or attack, BS.2.
  - Triplace of protection for the day bombardment, Bpr.3.
  - Biplace, lightly loaded for day bombardment and combat, Bn.2.
  - Multiplace, heavily loaded, night bombardment, long distance, Bn.4.
- Colonial.

Available motors for military aricraft.

Supply.	Type.	Horse-power.	Weight (in pounds).	Type of airplane.
20	Bugatti cannon	450	815	
1 experimental	De Dion	800	1,330	CAn.2.
Long series	Hispano	300	450	Bp.2.
10 on order	Hispano with Rateau	275–300	500	C.1, c.1, C.Ap.2, Bpr.3.
1 in study	Hispano cannon	400–450	....	
1,000	Liberty	370–400	600	A.2, BS.2.
Long series	Lorraine	270	420	CAn.2, A.2, BN.2.
700	...do	370	600	CAn.2, A.2, BS.2, BN.2.
1 building	Lorraine with gears separate	370	680	BN.2, BN.4.
1 experimental	Lorraine	500	760	CAn. 2, A.2.
200	Panhard, geared	330–350	675	
1 experimental	Panhard	500	850	C.1, c.1, C.Ap.2, CAn.2.
Do	...do	500	825	BS.2.
Do	...do	600	1,000	C.1, c.1, C.Ap.2, CAn.2, BS.2.
Do	Peugeot	500	825	A.2, BS.2.
Long series	Renault	280–300	510	CAn.2, A.2.
	Renault with Rateau	280–300	570	C.1, c.1, Bpr.3.
For study	Renault with reduction gears separate.	570	....	BN.2, BN.4.
900	Renault	380–450	720	A.2.
4 on order	Renault with Rateau	380–450	810	C.1, c.1, Bp.2, C.Ap.2.
1 in study	Renault with reduction gears	380–450	....	BN.2, BN.4.
10 experimental	Renault	550–600	940	C.1, c.1, C.Ap.2, CAn.2, A.2.
1 being studied	Renault with Rateau	550–600	1,020	C.1, c.1, Bp.2, CAp.2, Bpr.3.
Long series	Salmson	230–260	385	CAn.2, A.2.
25	....do	460–550	....	C.1, c.1, C.Ap.2.
Long series, rotary	Clerget	130	190	BS.2.
	...do	200	270	
	Rhone	120	175	
	...do	170	200	

HANGARS.

Hangars and hangar construction can well be considered under a discussion of French aeronautics, since that country has examples of every type of hangars that are to be found in Europe. Some of these are distinctly German but have become the property of France through the terms of the treaty of Versailles.

Five huge hangars have been constructed at Le Bourget, on the outskirts of Paris, which are intended to house the huge military and commercial airplanes of to-morrow. They will be used immediately as a part of the equipment of the Paris air port.

These huge structures are 125 feet wide by 250 feet long and are built of concrete and steel. The floors and hangar wall bases are of concrete and the main structure is built of steel trussing with main frames pin-jointed to the hangar base. The doors are of the overlapping panel type and are electrically operated. When the doors are entirely opened the total floor area consumed, due to the overlapping of all the door panels, is not any greater than one door panel. The doors are very thick and are of steel truss structure mounted on huge truck wheels. These engage with a track running parallel with the face of the hangar and are guided at the top by rails and wheel guides. Careful attention has been paid to reduction of the rolling friction to a minimum, and these doors have been found very easy to open and close.

The heating of these hangars will be by a hot-air system, and the intention is to keep the hangars at a temperature about 10° above that outside. On each side of the hangars small storerooms and workshops have been built.

The lighting system is very unique. It is effected principally by skylights that have been incorporated in the construction. These hangars are constructed to be permanent. Many others are to be constructed in addition to those already begun.

Another type is the new dirigible hangers that are being built at Orly to house the large dirigibles that the French Air Service expects to construct. These hangars will be entirely of concrete construction with the internal truss. They are of the crown type with sloping sides and with huge concrete abutments. They are designed so as to resist the effect of possible bombardment from the air.

These hangars will have a free space of 150 feet and are 1,000 feet in length. They constitute an enormous project, representing the expenditure of a huge sum of money, and are conclusive evidence of the faith that the French have in the future of military and commercial aeronautics.

A free space is provided around these hangars so as to obviate as far as possible the danger of fire and to limit the amount of damage in case of explosion from any cause whatever. The hydrogen plants, which are of permanent construction, are also isolated and far from any of the more important buildings.

The hangars occupied by the French bombardment regiment at Neustadt constitute an interesting study. This airdrome was constructed and occupied by the Germans during the war. The hangars are not high enough but are well constructed throughout. The construction is of concrete with concrete floors. Most important is their unique heating system. Underground hot-air pipes empty into several floor vents about 6 inches in diameter located about every 25 feet. They are practically underneath the stall space that would ordinarily be occupied by an average machine. These holes are flush with the floor surface and can be covered with ventilated cover plates.

In cold weather little hot-air stoves can be installed over each of these holes to allow better diffusion of heat. Keeping the mechanicians warm greatly increases their efficiency. Flexible Greenfield type duralumin hose is also provided in all these hangars in different lengths to allow heat to be carried to the individual machines at night. The motor compartments are thus supplied with hot air from the outlet vents in the floor. The idea is to keep the oil in the motor compartment from congealing during cold weather and to facilitate starting. No interference with the passage or location of the machines in the

hangars is occasioned on account of these installations. This individual piping of hot air to the machines at night in cold weather was the only instance that was noticed in any of the hangars abroad.

Zeppelin hangars are being transported from Germany to France and to Italy and are being installed at Cuers and Cianpiano. At Staaken, just outside of Berlin, a steel Zeppelin hangar is being dismantled tor shipment to France. The doors of this huge hangar are of the semicircular panel type, opening in an arc.

The airplane hangars occupied by the French along the French-German frontier in the temporarily occupied zone where hangars were not already existing are of the Bessoneau type. These are the well-known type with demountable wood frame and canvas covering. However, several airdromes which are now occupied by the French were formerly occupied by the Germans, and hangars of semipermanent and permanent construction are found.

We can very well take a lesson from the experiences of the Allies as to methods of hangar and door construction, heating and lighting. Door suspension and handling are vital to the life of a hangar, and it is essential that they be capable of being opened and closed easily and quickly to permit ingress and egress of machines under all weather conditions with the use of a minimum number of men.

LAMBLIN RADIATORS.

The Lamblin type radiator is being used in France on practically all the latest types of airplanes. A great deal of foreign criticism has been directed at this type of radiator on account of the apparent difficulties of manufacture. The difficulty of making repairs, of mounting and of transporting, have also been criticized.

The primary reason advanced for the use of this type of radiator is the simplicity and ease with which it can be placed in a free-air position apart from the fuselage or wings. Most installations have been underneath the fuselage and in the landing gears. However, others have mounted them on the sides of the fuselage and on the bottom wing. This radiator minimizes the parasite head resistance required for cooling the motor. The best installation is the one used on the Nieuport 29, and claims have been advanced that the fine performance and speed characteristics of this airplane are attributable in no small measure to the low resistance of the Lamblin cooling system. The French Air Service has placed orders for 200 of the Nieuport 29 single-seaters with Lamblin radiator installations, which is significant of their faith in the merits and serviceability of this type.

The radiator mounting on the Nieuport 29 is of the twin support type and allows for ease of demountability in the fields. Some designers stated that the Lamblin radiator aids them in balancing their machines on account of the simple nature of the mounting required and the ease of moving the position of the radiator.

The radiator in itself is rather expensive to construct. It consists of about 100 elements. The manufacturers stated that there were approximately 4,500 operations in the completed radiator and that all the radiator elements are alike and interchangeable. The radiator elements allow a very high degree of expansion and are said to hold up very well under freezing conditions. The elements can be readily detached in the field by unfastening five soldering wires, the inlet and outlet collector ring, and the two annular circuiting rings. Samples of the elements in their various stages of manufacture were procured in order to furnish our engineering division with first-hand information as to the actual problem in the manufacture as well as the facility of repair. These have already been forwarded to the chief of the engineering division.

They are nested in felt-lined cradles and are mounted singly or in pairs in boxes for transportation. These radiators cost about $100 apiece in France.

EX-GERMAN ZEPPELIN "L-72."

The *L-72* was surrendered by the Germans to the French under the terms of the treaty. It is fully assembled in the hangar at Cuers. It is supported by blocks all along the frame. Parts of the motors have been removed from the nacelles and all are well blocked to take the weight off the frame. The spares are well stored in rooms along the side of the hangar and are receiving good care.

The great ship was thoroughly inspected and we were impressed mostly by the lightness of her construction and the perfection of the detail. Her frame is all built of triangular truss construction. She has a keel that runs from one end to the other inside her envelope that is somewhat similar to the keel in the *Roma* but inverted. Of course it is not flexible. This keel is the support to which the cat walk and all the tanks, ballast, compartments, etc., are attached.

Tke *L 72* has been renamed the *Dixmude* by the French. She is 227 meters long and 24 meters wide. She has a radius of action of 18,000 kilometers at 50 kilometers per hour, or will carry 7 tons of bombs for 12 or 15 hours at the same speed. Her normal crew is 5 officers and 25 men. Her officers are a commanding officer, three watch officers, and one officer mechanic. Plenty of sleeping quarters are provided and a fairly comfortable room for the officers and another for the commanding officer is built inside her envelope. No provision is made to cook food aboard.

This ship was built primarily to carry a load of bombs for a short distance at a great altitude. The tail surfaces are all internally braced but have a few wires on the outside as well for additional strength. She is motored with six Maybach motors of 245 horsepower, placed one in a rear nacelle underneath and in the middle, two pairs of two each along the sides and one immediately in the rear of the navigating cabin which is the middle of the ship in front. The front and rear motors turn 890 and the others 1,600 revolutions per minute.

The French reported that the ship was all ready to be used with the exception of the balloonets. These the French do not have. As it will require 200,000 cows to get the gold beater skins to make them, the *L-72* will likely be out of commission for some time.

The acquisition of the *L-72* has been a good thing for the French, for they have learned much from it that will be of great value in their lighter-than-air development.

FRENCH METEOROLOGICAL PILOT BALLOONS.

The French are using a simple device which is not only accurate but which saves considerable time in the inflation of their pilot balloons. This is merely a loaded brass spring valve constructed so that one end of the

valve fits into the throat of the pilot balloon and the other end into the hose of the hydrogen cylinder. The valve is so constructed that it can be weighted with sand or shot to the exact degree of buoyancy that the pilot balloon should have. The balloon is slightly overinflated and then the string placed on the valve. Gas is released until the balloon is in equilibrium and then the balloon is tied and the valve withdrawn. This simple device saves time.

PESCARA HELICOPTER AND HELICOPLANE.

Mr. Pescara has done a great amount of work to perfect a helicopter, and recently won the prize offered by the French technical section for the construction of a helicopter that would lift itself and pilot from the ground a distance of at least 1 meter and return to earth without mishap.

More recently Mr. Pescara has been devoting his energies to the production of a machine embodying the principles of both a helicopter and an airplane which he has styled a helicoplane. He stated that he had already received an order from the French Government to proceed with the construction.

This machine has upper and lower wings revolving in opposite directions. They are connected through gearing and clutches to a 300-horsepower engine situated immediately back of the wings in the fuselage. This motor is also connected through a clutch to a pusher propellor mounted at the rear end of the fuselage. The pilot sits immediately forward of the wings. The radiator is located in the front end of the fuselage. The machine will weigh 850 kilograms empty and 1,250 kilograms fully loaded. Surface loading will be approximately 80 kilograms per square meter.

The main vertical drive shaft to the helicoplanes proper terminates in the landing gear fork support and the vertical drive shaft housing alone forms the main support for the planes proper. Small counterbalancing ailerons are fitted at the extremities of the helicoplanes. Elevator, stabilizer, and rudder are mounted in conventional fashion. The tail skid is really an extra strut to the landing gear proper to keep the propeller away from ground interference.

In order to glide to earth in case the motor stops, Mr. Pescara claims that by varying the pitch of these helicoplanes and allowing them to be free to move they will revolve in opposite directions while gliding without power and thus increase the gliding distance appreciably. He claimed this would have practically the same effect as cutting down the loading to less than half of what it is with fixed planes.

Mr. Pescara is prepared to bring this machine to the United States under contract and guarantee its demonstration in a closed circuit under full control. Details of this arrangement can be procured from John M. Jahill, 334 Fifth Avenue, New York City. Mr. Jahill is Mr. Pescara's American representative.

ITALY.

RÉSUMÉ OF ITALIAN AERONAUTICAL ACTIVITIES.

Italy has had little incentive for the development of many new types of planes or motors since the war due to the huge accumulation of war supplies on hand.

The Italian Air Service has salvaged or otherwise disposed of the greater part of her old airplanes, but she has over 11,700 spare engines on hand, most of which have never been used, and with these figures always before them it is very difficult to convince the legislative bodies of the Government or the directors of the big industrial plants of the advisability of spending additional money for new engines. The result is that all designers of both new commercial and military types of airplanes are striving to create, and have created, better airplanes built up around the engines developed during the war. These engines have been in some cases considerably improved since the armistice by slight modifications. This is where Germany is more fortunate, from an aeronautical point of view, than any of the Allies, for having loaded all her obselete material upon the latter, she is free to direct all her studies, designs, experiments, and available money toward new constructions.

During the calendar year 1921 the following machines were produced:

Military machines manufactured for Italian Army	56
Naval seaplanes manufactured for Italian Navy	94
Commercial types produced	60

The 56 military machines were as follows:

Fiat BR, 700 horsepower	39
Macchi M 16 type	12
Miscellaneous	5
Total	56

The 94 naval machines, all seaplanes, were as follows:

Macchi M 7	50
Macchi M 18	20
Savoia S 13	18
Savoia S 12	2
R1 bis (3 IFV 6 motors)	2
PRB (4 IFV 6 motors now being changed to 4 Fiat A 12 bis motors)	2
Total	94

The commercial types constructed were as follows:

M 18 (seaplane)	6
S 16 (seaplane)	15
S 21 (seaplane)	2
S 22 (seaplane)	2
S 23 (seaplane)	2
Fiat type R	4
Ansaldo A 200	2
Ansaldo A 250	2
Ansaldo A 300, A 300 C, A 300 T	20
Breda triplane	1
Ricci R 9	2
Gabardini training machine	2
Total	60

Number and types, active service, army, per 1,000, are as follows:

Pursuit:	
Spad VII	96
Hanriot	144
Balilla	24
Bombardment:	
Fiat BR	24
Caproni 3	16
Observation:	
Samson	84
SVA	66
R2	12
School:	
Aviatik	200
Types above in same proportion	334
Total	1,000

Number and type, active service, in navy, are as follows:

Pursuit: M 7	40
Observation:	
S 13	30
M 9	50
Bombardment: Caproni 5	4
Total	124

Under orders for construction for the army:

Marchetti	12
Macchi	12
Ansaldo A 300	12
Caproni 450 (modified)	2
Stiavelli	2

Under orders for construction for the navy:

S 12 bis	10
S 23	2
S 25	2

Military types of machines built under war orders are being used in both the army and navy. Service squadrons will not be equipped with machines developed and constructed since the war prior to 1923. A few experimental types are constructed periodically as developed. If the types are found satisfactory at the experimental field and after a period of actual service with the experimental squadrons designated to give a service test to new types, they will be put into production to replace the old material. The first object will be to replace French types by new Italian types.

During the present year a special effort will be made to develop new military airplanes and engines in order to begin to equip the squadrons with new equipment during 1923.

Aeronautical technical research and development are being systematically carried out by the Institute of Experimental Aeronautics, by the Lighter-than-Air Constructing Establishment, by the Aerial Armament

Service, and by the Royal Polytechnic of Turin. The work of the latter place consists principally of aerodynamic studies.

The experiments and studies made at the Institute of Experimental Aeronautics are obtained by our military attaché, translated, and forwarded to Washington. Many of the studies made there are very important, especially those made by Colonel Crocco. Description and designs of the principal instruments used in their aerodynamic experiments, which were reported to the Engineering Division of our Air Service, should be very valuable.

The Lighter-than-Air Constructing Establishment has carried out interesting experiments with dirigibles, observation balloons, free balloons, and parachutes. The director gave us copies of reports on their most interesting studies and developments, which have been translated and forwarded.

The static test methods adopted by the Italians for testing out their aircraft have an embodiment of assumptions which are essentially different as regards the ultimate strengths required by aircraft under different flight load conditions. A copy in Italian of these standard test methods has been procured and is now being translated. However, a later and revised edition is now being prepared by the Italian Technical Experimental Institute and on completion of compilation will be tendered to our military attaché in Rome.

METAL CONSTRUCTION.

Mr. Dornier, of the Zeppelin Co. at Friedrichshaufen, intends to open up an airplane factory in Pisa and carry on the construction of his all-duralumin types of aircraft for Italian military and commercial purposes. This will, no doubt, have a strong tendency to revive interest and turn the trend of design toward all-metal construction in Italy. Italy has done very little with metal construction.

The only all-metal airplane in Italy to-day has been the Marchetti, which employs high alloy steel tubing for its basic construction. Their principal drawback for development in all-metal construction since the war has been lack of funds for experimental purposes, with subsequent reduced personnel and the lack of suitable materials.

In all new types steel is being almost entirely used for the following parts: Interplane struts; undercarriage struts; axles and practically the entire undercarriage; fuselage vertical struts and practically the entire framework of the fuselage except the longerons, which are of wood. The wing construction, spars, and ribs are entirely of wood. It is believed that the next stage of new construction in Italy will be the use of metal wing spars and the second stage will be the use of metal longerons in the fuselage construction. Some of the best engineers in Italy believe that a combination of wood and metal is the best for airplane construction. This is not the opinion, however, of the Experimental Institute. There, it is believed that in the near future the best airplane will be all-metal. Due to the lack of minerals in Italy, the adoption of metal construction will naturally advance slowly. Very little practical use has ever been made of duralumin in Italy and steel is therefore being used at present for the metal parts. The Italians are also naturally much better wood workers than metal workers and this is another consideration which retards the adoption of metal construction.

The Italians have always been noted for their wonderful woodworkers and woodworking facilities. The characteristic type of construction adopted and used in the Ansaldo, Savoia, Macchi, and S. V. A. types are wonderful examples of wood craftsmanship and design.

The tendency of future Italian types as designed to meet their latest specifications will mean an absolutely new order of machines, designed and constructed under these new projects with desired performances, which, if realized, will by far eclipse all their present and previous types.

SEAPLANES.

Their seaplane designs are particularly up to date, and each successive type represents an advantage in refinement over its predecessor. They have not done much work in development of multimotored flying boats outside of the new twin-motored tandem Savoia type and the P. R. B. 1 four-motored tandem type. The only multimotored bombardment types they have really developed to date are the Caproni.

THICK-WING AIRPLANE CONSTRUCTION.

No airplanes have been constructed of the thick-wing construction. Mr. Pegna has been designing an eight-engine seaplane of this type and has been receiving technical assistance from the Experimental Institute.

ENGINES.

The Anzani Co. is the only one in Italy that has actively constructed radial air-cooled engines. This firm has, however, made no improvements of interest. Their types 90 and 110, of 95 horsepower and 116 horsepower, respectively, are the most powerful that have been constructed by this firm. These motors have given very satisfactory service in school machines. It is reported that the Breda Co. is experimenting with a small type radial air-cooled engine. So far no information has been given out concerning the experiment. It is of 60 horsepower approximately.

The adoption of the 300-horsepower Hispano-Suiza engines for their latest pursuit-work development and also in other types equipped with superchargers, if procurable, although they have not developed any of these to date, will give them pursuit airplanes equal to French and English prototypes.

ARMAMENT.

The Aerial Armament Service has been carrying out systematic studies for the development of an efficient aerial gas bomb. These studies are considered secret, and naturally no detailed information is given out concerning the results. In approaching the chief of the Aerial Armament Service on this matter the following general information was obtained:

(a) The object in view is to develop a bomb with the gas compressed to 100 atmospheres.

(b) To obtain a bomb that is not to explode on impact, but to permit a gradual escape of the highly compressed gas or gases.

The Aerial Armament Service has also recently made experiments with an aerial bomb with long-delay fuses developed by General Giampietro. The fuses of these bombs can be set for different bursting times, the maximum being six hours. These bombs are to be transported by airplanes and dropped over a selected zone, such as an industrial center; for example, the zone thus being subjected to explosions for six hours. At the end of five or six hours the zone will be bombarded again, thus keeping it continually subjected to explosions. The moral effect of such bombs in an industrial center would be very great. The fuse is reported to have worked satisfactorily at all settings up to six hours in the practical experiments carried out. General Giampietro stated that Japanese agents were trying to purchase this type of fuse.

FLYING BOMB, ITALIAN.

One of the most interesting things in bomb construction was an aerial torpedo bomb of about 12 kilograms that was designed for operation against distant objects, to be dropped from an airplane at a height of 1,500 meters. It is about 10 inches in diameter and about 5 feet in length. Its wing span is approximately 4½ feet with a dihedral of about 3°. The wings are braced in Warren truss fashion. It is the concussion type of bomb, carrying the charge in the nose. Directly behind the charge is a small compressed-air chamber. The compressed air actuates a gyro which maintains the stability of the bomb by holding the rudder in place. The elevator is set to maintain the correct gliding angle and then to dive vertically. This is done by connecting the elevator to a cam which is revolved slowly by the action of a propeller on the tail of the bomb. This propeller, of course, is actuated by the reaction afforded by the movement of the bomb through the air. The wing area of this bomb is about 8 feet. This bomb can be used for bombing objectives at a distance of approximately 12 kilometers, thus giving the airplane or dirigible dropping the bombs that point of advantage in distance against defensive antiaircraft fire from the objective to be bombed. It has been tried out by the Italian Air Service with satisfactory results.

NEW DIRIGIBLES.

One thousand one hundred cubic meter semi-rigid dirigible.—This new type is being developed primarily as a preliminary training ship for dirigible pilots and secondarily for coastal reconnaissance duty in time of war and for pleasure and touring in time of peace. One of this type is practically completed and will be seen at Ciampino. Its characteristics are:

Type: Semirigid, with perfect continuous keel.
Volume: 1,100 cubic meters.
Power plant: Two 6-cylinder, 35 horsepower Anzani, radial, air-cooled engines.
Speed: 75 to 80 kilometers per hour.
Endurance: 10 hours with one motor; 5 hours with two motors.
Crew: 2.
Passengers: 2 to 3.
Cost: 160,000 lire, or $8,000.

New 46,000 cubic meter dirigible.—The plans and detailed drawings for this new dirigible (semirigid) have been completed. The Government has not yet given the order to begin work due to lack of funds by the air service. Its characteristics are as follows:

Type: Semirigid, *Roma* type.
Volume: 46,000 cubic meters. (*Roma*, 34,000 cubic meters).
Power plant: 10 SPA 6-A motors, each of 200 horsepower.
Speed: Maximum 110 kilometers per hour; cruising speed, about 90 kilometers per hour.
Range: 7,000 to 8,000 kilometers.
Passengers: 30 to 40 comfortably; there will be four cabins, each 5 meters long.

One hundred and twenty thousand cubic meter semirigid dirigible.—Engineer Usuelli, the designer of the *Roma*, has just completed all the plans and detailed drawings for his new dirigible of 120,000 cubic meters. He is trying to interest the Italian Air Service in this matter in order to have the preliminary work well under way in order to construct the dirigible in one of the large hangars obtained by Italy from Germany, which is expected to be erected at Ciampino in the near future. The Italian Government has as yet made no definite decision in this matter. He showed General Mitchell a concise description of this type with its characteristics and cost of construction.

Experiments on dirigible rudders and elevators.—One of the O type semirigid dirigibles (3,600 cubic meters) at Ciampino has had the rear part of its envelope made rigid, and the elevators and rudders have been attached directly to this tail stiffening instead of being placed under the rear part of the envelope, as has been the practice heretofore in dirigible construction in Italy. The tail planes have been attached in a manner very similar to that employed in the Zeppelins. Experiments with this modified O type have been carried out.

Maximum speed has been increased from 91 to 96 kilometers per hour and better results are expected. From the results obtained it is safe to state that this system of tail planes and rudders will be adopted in all future dirigible construction in Italy.

ITALIAN TYPE SPECIFICATIONS.

The Italians are not building planes in large numbers at the present time. They have made a careful study of the aeronautical problem and have drawn up type specifications for their various types of planes.

For three months or more a board of aeronautical engineers (army and civilian) have been drawing up the characteristics to be required of new military types to be produced during 1922 and to be put in service in 1923. The types are the following:

Night bombardment.
Day bombardment.
Ground attack or battle airplane.
Tactical reconnaissance.
Strategical reconnaisance.
Day pursuit.
Night pursuit.

The required characteristics of each of these types have just been obtained. They are of interest and value and are attached hereto.

NIGHT BOMBARDMENT MACHINE.

(a) Crew: Two pilots. Dual control. Posts for two pilots seated side by side and must have excellent visibility. Two mechanic machine gunners.

(b) Armament: Two groups of Fiat machine guns with 1,000 rounds of ammunition, for forward and rear defense. One machine gun for firing downward.

(c) Installations: Fixed accessories for installing radio equipment (receiving and transmitting). Navigating lights; device for illuminating the ground when landing; internal lighting system for reading the instruments.

(d) Instruments: Oil and gasoline manometers (if the tanks are not of the gravity type, altimeter, tachometer, aerothermometer (for the radiators), speed indicator either Pitot or Venturi tube, compass, clock, inclinometer, and map holder.

(e) Bombs: One thousand kilograms of bombs. The installation must be capable of carrying two different types of bombs. It must be possible to carry two large bombs weighing 500 kilograms each.

(f) Endurance: Normal load of oil and gasoline sufficient for a flight of 4 hours and 30 minutes at a speed of 140 kilometers per hour, and at an altitude of 1,000 meters, with machine complete with crew, armament, installations, and bombs. The tanks must be capable of holding sufficient oil and gasoline for a flight of seven hours at a speed of 140 kilometers per hour at a height of 1,000 meters. In this latter case the load of bombs will be decreased in proportion to the increase in the normal load of fuel.

(g) Maximum velocity: With machine fully loaded and at an altitude of 2,400 meters the maximum speed must not be less than 150 kilometers per hour.

(h) Minimum velocity: Minimum velocity must not exceed 75 kilometers per hour at 500 meters with a full load of crew, arms, instruments, installations, and sufficient fuel for one hour's flight, but minus the load of bombs.

(i) Climb: Two thousand meters in not over 18 minutes with the machine fully loaded. (A machine is understood to be fully loaded when it carries the entire crew, arms, munitions, various installations, and instruments complete, the normal load of bombs, and the normal load of oil and gasoline.)

(j) Engines: The machine must be multiengined and equipped with mufflers; the motors must be accessible for the mechanics during flight.

(k) Coefficient of safety in the static test: The coefficient of safety in the static test with respect to conditions of a full normal load must not be inferior to 6.5. In every case this test must fulfill the rules prescribed by the Institute of Experimental Aeronautics for carrying out the static tests, due account being taken of the characteristics of the machine.

DAY BOMBARDMENT MACHINE.

(a) Crew: Dual control; the pilots are seated side by side; one machine gunner.

(b) Armament: One pair Fiat machine guns for rear firing, with large firing sector and an allowance of 1,000 rounds of ammunition; one fixed machine gun.

(c) Installations: Fixed accessories for installing radio equipment (receiving and transmitting) and camera.

(d) Instruments: Same as for night bombardment machine.

(e) Bombs: Normal load of bombs not less than 340 kilograms. The bombs to be arranged, if possible, inside the machine. The installations must be capable of carrying at least 500 kilograms of bombs (for short bombing trips). In this latter case the normal load of fuel is understood to be decreased proportionally. The installations must be capable of carrying at least two different types of bombs.

(f) Endurance: Normal load of oil and gasoline sufficient for a flight of five hours at a speed of 240 kilometers per hour at an altitude of 3,000 meters, with machine complete with crew, armament, installations, and bombs.

(g) Maximum velocity: With machine fully loaded and at an altitude of 2,000 meters the maximum speed must not be less than 260 kilometers per hour.

(h) Minimum velocity: Minimum velocity must not exceed 90 kilometers per hour at 500 meters with entire crew, fuel sufficient for one hour's flight and without bombs.

(i) Climb: Three thousand meters in not over 15 minutes, with machine fully loaded.

(j) Coefficient of safety in the static test: The coefficient of safety in the static test with respect to conditions of a full normal load, must not be inferior to 11. In every case this test must fulfill the rules prescribed by the Institute of Experimental Aeronautics for carrying out the static tests, due account being taken of the characteristics of the machine.

(k) Preference conditions: Under the same conditions, preference will be given to multiengined machines. Having the engines fitted with mufflers will be a preference condition also.

GROUND ATTACK OR BATTLE MACHINE.

(a) Crew: One pilot and one machine gunner; machine with dual control.

(b) Armament: Two fixed machine guns in front for firing forward and one pair in the rear for rear fire, and device for firing downward. Aggregate weight of machine guns and ammunition, 200 kilograms at least.

(c) Installations: Fixed accessories for installing a camera. In the event of a camera installation, the weight of bombs decreases in proportion.

(d) Instruments: Same as for night bombardment machine less compass.

(e) Bombs: Normal load of bombs, 100 kilograms.

(f) Endurance: Load of oil and gasoline sufficient for a flight of 2 hours and 30 minutes at a speed of 130 kilometers per hour and at an altitude of 500 meters, with machine complete with crew, armament, and bombs.

(g) Maximum velocity: With machine fully loaded and at an altitude of 500 meters the maximum speed must not be less than 140 kilometers per hour.

(h) Minimum velocity: Minimum velocity must not exceed 70 kilometers per hour at 500 meters with a full complement of crew, fuel for 30 minutes' flight, but without bombs.

(i) Climb: Two-thousand-five-hundred meters in not over 30 minutes with machine fully loaded.

(j) Armor: A special armor for protecting the pilot, the machine gunner, the engine, the gasoline and oil tanks and the radiator.

(k) Cellule and fuselage: Elements of the cellule and fuselage must be of metal except wing spars and fuselage longerons.

(l) Coefficient of safety in the static test: The coefficient of safety in the static test with respect to conditions of a full normal load must not be inferior to 7. In every case this test must fulfill the rules prescribed by the Institute of Experimental Aeronautics for carrying out the static tests, due account being taken of the characteristics of the machine.

TACTICAL RECONNAISSANCE MACHINE.

(a) Crew: One pilot, one observer, and one machine gunner. Machine is equipped with dual control.

(b) Armament: One pair Fiat machine guns for rear fire with large firing section and an allowance of 1,000 rounds of ammunition.

(c) Installations: Fixed accessories for radiotelegraphic and radiotelephonic receiving and transmitting plants, and for two cameras; navigating lights; device for illuminating the ground on landing: and interior illumination for reading the instruments.

(d) Instruments: Same as for night bombardment machines.

(e) Endurance: Load of gasoline and oil sufficient for a flight of three hours at a speed of 180 kilometers per hour and at an altitude of 2,000 meters, with machine complete with crew, armament, and installations.

(f) Maximum velocity: With machine fully loaded and at an altitude of 3,000 meters the maximum speed must not be less than 190 kilometers per hour.

(g) Minimum velocity: Minimum velocity must not exceed 90 kilometers per hour with full complement of crew, machine gun with 500 rounds of ammunition, radiotelegraphic and radiotelephonic equipment, photographic machine complete, and fuel for one hour's flight.

(h) Climb: Three thousand meters in not over 20 minutes with machine fully loaded.

(i) Coefficient of safety in the static test: The coefficient of safety in the static test with respect to conditions of a full normal load must not be inferior to 9. In every case this test must fulfill the rules prescribed by the Institute of Experimental Aeronautics for carrying out the static tests, due account being taken of the characteristics of the machine.

STRATEGICAL RECONNAISSANCE MACHINE.

(a) Crew: One pilot and one machine gunner.

(b) Armament: One machine gun for forward fire and one for rear fire.

(c) Installations: Fixed accessories for installing two cameras and for a radiotelegraphic plant.

(d) Instruments: Same as for night bombardment machine.

(e) Endurance: Load of gasoline and oil sufficient for a flight of five hours at a speed of 230 kilometers per hour at an altitude of 3,000 meters, with machine complete with crew, armament, and installations.

(f) Maximum velocity: With machine fully loaded and at an altitude of 3,000 meters the maximum speed must not be less than 250 kilometers per hour.

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(g) Minimum velocity: Minimum velocity must not exceed 100 kilometers per hour at 500 meters, with full crew, installations, and armament complete, and fuel for one hour's flight.

(h) Climb: Five thousand meters in not over 30 minutes with machine fully loaded.

(i) Coefficient of safety in the static test: The coefficient of safety in the static test with respect to conditions of a full normal load must not be inferior to 11.5. In every case this test must fulfill the rules prescribed by the Institute of Experimental Aeronautics for carrying out the static tests, due account being taken of the characteristics of the machine.

DAY PURSUIT MACHINE.

(a) Crew: Monoplace machine.

(b) Armament: Two Vickers machine guns for forward fire with an allowance of 1,000 rounds of ammunition.

(c) Installation: Device which permits the flight commander to transmit orders; and one camera.

(d) Endurance: Load of oil and gasoline sufficient for a flight of three hours at a speed of 250 kilometers per hour at an altitude of 4,500 meters with machine complete with crew, armament, and installations. Fireproof tanks.

(e) Instruments: Same as for night bombardment machine, less compass.

(f) Maximum velocity: With machine fully loaded and at an altitude of 2,000 meters the maximum speed must not be less than 270 kilometers per hour.

(g) Minimum velocity: Minimum velocity must not exceed 110 kilometers per hour at 500 meters with full armament and installations, and fuel for 30 minutes' flight.

(h) Climb: Five thousand meters in 15 minutes with machine fully loaded.

(i) Coefficient of safety in static test: The coefficient of safety in the static test with respect to conditions of a full normal load must not be inferior to 12. In every case this test must fulfill the rules prescribed by the Institute of Experimental Aeronautics for carrying out the static tests, due account being taken of the characteristics of the machine.

NIGHT PURSUIT MACHINE.

(a) Crew: Monoplace machine. Visibility must be excellent.

(b) Armament: Two Vickers machine guns for forward fire with an allowance of 1,000 rounds of ammunition.

(c) Installations: Device for illuminating the ground on landing; navigating lights; internal lighting system for reading the instruments.

(d) Exhaust and muffler: A device for hiding the glare of the exhaust; a muffler. The pilot must be able to open up the exhaust when desired.

(e) Instruments: Same as for night bombardment machine, less compass.

(f) Visibility: The pilot's seat must give excellent visibility for the particular employment for which the machine is destined as well as for maneuvering for a landing.

(g) Endurance: Load of oil and gasoline sufficient for a flight of four hours at a speed of 150 kilometers per hour,

and at an altitude of 3,500 meters with machine complete with crew, armament, and installations.

(h) Maximum velocity: With machine fully loaded and at an altitude of 2,000 meters the maximum speed must not be less than 160 kilometers per hour.

(i) Minimum velocity: Minimum velocity must not exceed 60 kilometers per hour at 500 meters with complete armament and installations, and fuel for one hour's flight.

(j) Climb: Five thousand meters in not over 25 minutes with machine fully loaded.

(k) Coefficient of safety in the static test: The coefficient of safety in the static test with respect to conditions of a full normal load must not be inferior to 8. In every case this test must fulfill the rules prescribed by the Institute of Experimental Aeronautics for carrying out the static tests, due account being taken of the characteristics of the machine.

ITALIAN EXPERIMENTAL STATION.

The Italian Experimental Station, under the direction of Colonel Verduzio, is located on the outskirts of Rome. It is a fairly well-equipped station for aeronautical experimental and research work. However, its activities were necessarily curtailed by the financial conditions existing throughout Italy. Comparatively little work was being done, but the subjects which are of greatest interest to Italy were being investigated as far as the available funds would permit.

The Crocco wind tunnel, which is universally known, is housed in this institute. The Crocco tunnel is of the closed circuit type, driven by a 17-bladed wind screw at the rate of 450 revolutions per minute. A 150-horsepower engine is the source of power. This tunnel is sufficiently well known to make further description unnecessary.

The institute also houses three small-scale tunnels which have been constructed for instructional purposes.

The most interesting device for studying air flow was one which was being tried out in an endeavor to be able to actually see the disturbance of air behind a surface. They hope to achieve this by means of a long telescope and an electric spark jumping across a gap. Some degree of success had been achieved, but considerable work remained to be done. This device was carefully inspected, but in its present stage of development does not warrant greater description. Their altitude chamber offered nothing novel.

The Italians, of course, are most interested in lighter-than-air machines and this branch of aviation is receiving the bulk of attention. Exhaustive tests are being conducted on the proper streamlining for dirigible shapes, cars, engine nacelles, surfaces, keels, etc. These are conducted both in the wing tunnel and in the tanks. Right in line with this development, considerable work was being done to determine the strength of fabrics. Tests were being conducted to determine the breaking strength and the ga pressure under which it would fail. Any number of tests were being conducted to determine the permeability of the fabric by exposure to the weather when the fabric was under constant gas pressure. Other permeability tests were being conducted to determine the effect of the chemicals in the gas on the texture of the fabric and its permeability when subjected to tests under high-powered mercury vapor lamps while withstanding various pressures of gas. This mercury vapor light is supposed to be a more severe test than ordinary sunlight. Any number of methods are being used to determine the amount of leakage of gas through the fabric and the Italians have done a great deal of work in the perfecting of rubberized gas bags.

The usual facilities had been installed for testing metals, and most of the work being done along this line was in conjunction with steel tubes to be used in dirigible frames.

It is interesting to note that most of the experimental work being done with dirigible shapes contemplates both the nose and tail of the ship being constructed with a framework as a part of the flexible keel. All control surfaces were internally braced. The engines were all mounted on outriggers and all fuel was kept out of the main cabin.

Some interesting development work has been done with parachutes, not only of the single-man type but parachutes to drop baskets from kite balloons. There is nothing new or novel about any of their parachutes, but there was a rather clever device to release the parachute from the basket or man as soon as it strikes the ground.

Much attention is being given to seaplane development, and any number of tests were being conducted in a large model basin, 600 meters long by 3 meters wide. A third-rail system handles the model and devices are provided for procuring accurate readings.

Rather interesting results have been obtained with a whirling arm mounted over a tank of water.

One of the most interesting developments of the Italian technical section was the Italian flying bomb, or the "Teleo" bomb, as it was called. This is adequately described in the "Résumé of Italian Aeronautical Activities."

They also had an interesting target airplane which is fully described under the appropriate heading.

The activities of the Italian aeronautical section show that the personnel is working hard and conscientiously to develop new equipment and to improve their present machines, but the lack of financial support is evident and the entire establishment gives the impression of being practically abandoned.

ITALIAN DIRIGIBLE.

Mr. Usuelli has projected a dirigible known as the T-120, of 120,000 cubic meters, the designing of which has practically been completed.

The endurance of the T-120 will exceed 15,000 kilometers. Such an endurance is attainable with the full navigating equipment and a useful load of 100 passengers and relative baggage. The cruising speed will be 90 kilometers per hour, to attain which only one-half of the engine power is used. There is, therefore, a reserve engine power of 100 per cent. It running under full power the airship would have a speed of 120 kilometers per hour. This power is subdivided into eight engine nacelles with double engine and double propeller. The engines are of 250 horsepower. Unlike the dirigible *Roma*, the engine nacelles in the T-120 are suspended by cables; that is to say, they consist of a suspended car of a penetrating form with a rigid bridge and gangway.

The commander's cabin is located in the prow and has a splendid field of visibility. Next to it is the passengers' cabin which is divided by a wide corridor. Armchairs or beds may be easily installed. The nose and stern are rigid. The rudders and elevators which are of monoplane type are fastened to the keel by internal bracing. This tail is markedly superior to the one on the *Roma*.

The keel is triangular.

The airship can be very readily transformed into a war type for bombardment work at great distances. If this was desired, the passengers' cabins could be replaced by a distributed load of 10 tons of bombs or aerial torpedoes. With full war equipment this airship could easily attain an altitude of 5,000 meters.

This ship is the semirigid type with a keel running from bow to stern. Both bow and stern are rigid. Three round, steel tubes are welded into ball-and-socket joints at each end to form the units used to construct the ship. These are then used in lengths of 5 to 10 meters each to form a great triangular keel. Superimposed above this triangular frame are other members which continue the sides of the triangle up to the envelope.

The gas is carried in numerous compartments as is standard practice with semirigids. The envelope is held in shape by air pressure.

With their intimate knowledge of semirigids and their expertness with fabric, the Italian could turn this ship out in a very creditable way and it would be a valuable addition to the aeronautical equipment of any nation.

SAVOIA FLYING BOATS.

The Savoia Co. are the best seaplane and flying boat constructors in Italy. Their interpretation of hull construction evidences marked superiority of design and craftsmanship and entitles them to rank high among the world's best air-boat constructors. Their seaplanes are also very good, and the performances attained with their different models have been comparable with best results attained anywhere.

In their hull construction they employ walnut longerons, ash ribs, and poplar veneer covering. The workmanship is excellent and the care exercised in the detail work is remarkable. Their wings do not differ from other wings in design or construction. However, the fin is built integral with the aft end of the hull and is very thick to provide a good mounting base for the empennage proper.

The tail control countershaft is located in the fin. The entire tail plane, which is generally very wobbly on flying boats, in this case is very rigid. An interesting feature in their tail plane construction is the way the two spars in the stabilizer are supported by one steel tube brace. To the usual steel tube which runs from the fuselage to the rear spar is welded another tube in Y fashion to support the front spars. This provides a rigid brace for both longerons without the necessary addition of a second tube. This idea could be utilized on all planes.

The engine is mounted in such a way that four struts can be removed and then the engine and entire mounting structure removed in short order. The engine mounting is very simple and permits great accessibility to the engine. The gas tanks in all Savoia models are suspended from the engine mounting.

They employ nose radiators in all of their types. The hull bottoms are all concave. Ailerons are provided on the top planes only. Four-bladed propellers of their own manufacture are used. Adequate provision is made everywhere for inspection. In front of the pilot is a single cockpit for the navigator or the gunner. Provision is made to transform their ships into bombers by the addition of bomb racks on the underside of the wings

SAVOIA S-13.

This machine has been adopted for reconnaissance work by the Italian Navy.

The bottom and sides of the boat up to the water line and also the bulkhead are constructed by placing the struts of the engine bed diametrically.

The tail surfaces with internal controls have been located much higher and the bottom of the rudder has been covered with sheet metal to avoid injury in the water.

This machine will have the Hispano-Suiza 300-horsepower engine substituted for its present Isotta power plant.

Spain has recently ordered 12 more of this type, as she has had a great deal of satisfactory service with them in Morocco.

Characteristics of the *S-13* are as follows:

Span: 11.08 meters.
Length: 8.99 meters.
Height: 3.16 meters.
Motor, Hispano-Suiza: 300 horsepower.
Area: 40.60 square meters.
Weight, empty: 1,000 kilograms.
Useful load: 400 kilograms.
Total weight: 1,400 kilograms.
Load per square meter: 34 kilograms.
Velocity: 200 kilometers per hour.
Chord of upper wing: 1.90 meters.
Chord of lower wing: 1.55 meters.
Tail span: 5 meters.
Hull length: 8.49 meters.

SAVOIA S-16 BIS.

This is an improvement over the original *S-16*. The tail surfaces have been raised and the area has been increased. The lower wings have been given lateral dihedral in order to obtain greater lateral stability. Ailerons are fitted to the lower wing only. The attachments of the wing floats to the bottom wing have been simplified and reduced in number so as to cut down head resistance. This machine carries six passengers, including the pilot. It has a range of 600 kilometers. The first of these machines have been purchased by Spain. Characteristics of this type are as follows:

Span: 15.50 meters.
Total length: 9.97 meters.
Total height: 3.67 meters.
Motor, Fiat A-12 bis: 300 horsepower.
Total area: 59.15 square meters.
Weight, empty: 1,700 kilograms.
Useful load: 750 kilograms.
Total weight: 2,450 kilograms.
Load per square meter: 42 kilograms.
Maximum speed: 170 kilometers per hour.
Chord of upper wing: 2.20 meters.
Chord of lower wing: 1.85 meters.
Hull length: 9.39 meters.
Tail span: 3.80 meters.

SAVOIA S-19.

This is the racing type that was especially constructed for the Schneider cup race. It is one of their standard flying boat types equipped with the 450 horsepower Ansaldo-San Giorgio engine. Speed of the machine is 238 kilometers per hour. The company is reserving this type for some future race and it has been impossible to obtain characteristic data on that account.

SAVOIA S-22.

This machine is a twin-motored, tandem job, equipped with two Isotta 250-horsepower engines.

Speed: 225 kilometers per hour.
Ceiling: 6,000 meters.
Endurance: 4 hours.
Total weight: 2,500 kilograms.
Weight, empty: 1,600 kilograms.
Useful load: 900 kilograms.
Span: 13.50 meters.
Length: 10.78 meters.
Height: 3.52 meters.
Coefficient of safety: 8.

SAVOIA S-21.

Speed: 280 kilometers per hour.
Motor, Ansaldo: 300 horsepower.
Ceiling: 5,000 meters.
Endurance: 1½ hours.
Total weight: 900 kilograms.
Weight, empty: 70 kilograms.
Useful load: 200 kilograms.
Span: 7.69 meters.
Length: 7.62 meters.
Height: 2.64 meters.
Coefficient of safety: 11.

This machine is one of the latest speed jobs which they have constructed and tested.

SAVOIA S-23.

Span: 12.440 meters.
Height: 3.230 meters.
Length: 9.990 meters.
Passenger capacity: 2.
Motor, Isotta: 160 horsepower.
Area: 43.39 square meters.
Weight, empty: 1,143.9 kilograms.
Total weight, loaded: 1,385 kilograms.
Load per square meter: 31 kilograms.
Hours of flight: 2½ hours.
Velocity, minimum: 75 kilometers per hour.
Velocity, maximum: 155 kilometers per hour.

This is a type of school machine. It has a supporting area slightly inferior to the *S-13*. It is very strongly built. The boat is covered, as are all the other Savoia types, with veneer planking. The small auxiliary wing floats are of veneer also. Ailerons are fitted to the lower wings only. The tail surfaces are of the raised type and have internal controls. It is equipped with a four-bladed propeller. Its flying qualities have been pronounced very excellent for instructional purposes. It has a marked degree of responsiveness to controls. Twenty-five of these have been purchased by Spain.

SAVOIA S-24.

This machine is constructed along the same lines as the *S-22*, but is much larger and intended principally for civilian use. Two motors are installed in tandem. The machine is of the two-bay wing-truss type and will accommodate approximately 10 to 12 passengers. The first machine has been completed and its speed is 170 kilometers per hour. It is expected to attain a speed of approximately 150 kilometers per hour with one engine. This machine has a biplane tail. The passengers are totally inclosed in the hull, while the pilot and mechanic are placed forward.

Characteristics of this machine are as follows:

Span: 19 meters.
Length, over all: 13.30 meters.
Total height: 4.75 meters.
Motor, Fiat A-12 bis: 300 horsepower.
Total area: 98.75 square meters.
Weight, empty: 2,600 kilograms.
Useful load: 1,600 kilograms.
Total weight: 4,200 kilograms.
Surface load: 43 kilograms per square meter.
Velocity: 170 kilometers per hour.
Chord of upper wing: 2.8 meters.
Chord of lower wing: 2.56 meters.
Span of tail: 4 meters.

The Savoia firm has recently acquired the services of Mr. Marchetti and will construct 12 Marchetti land pursuit airplanes for the Italian Air Service. No examples of this machine have been constructed other than the two officially tested out by the Army Air Service in 1919. This machine was credited with a speed of 270 kilometers per hour.

MACCHI SEAPLANES.

The Macchi Co. is one of the most expert seaplane construction companies in the world. The design, craftsmanship, and performance of their product are excellent.

The engineers of the Macchi Co. are now studying a new, bimotored, torpedo-carrying seaplane for the Italian Navy. No definite information could be secured in reference to this model other than it would have the conventional Warren wing truss used by the Macchi Co., and the parabolic, concave V bottom that characterizes all their machines. The motor mount will be of the truss type and it will have a nose radiator.

Their last new machine was the *Macchi 19*, or *M-19*, as it is familiarly called. This was a biplane seaplane powered with a 700 Fiat motor.

The Macchi Seaplane Co. has a very interesting little, two-seater sport type seaplane, powered with a three-cylinder Anzani engine of 30 horsepower.

The total area is: 11.3 square meters.
Weight, empty: 160 kilograms.
Useful load: 100 kilograms.
Total weight: 260 kilograms.

The useful load is made up of:

Pilot: 70 kilograms.
Fuel: 30 kilograms.
Span: 6 meters.
Length: 4.22 meters.
Height: 2.12 meters.
Velocity, maximum: 130 kilometers per hour.

Landing speed: 4 kilometers per hour.
Load factor of safety: 12.
Range: 420 kilometers.
Climb to 1.000 meters: 9 minutes.
Climb to 2.000 meters: 22 minutes 40 seconds.
Climb to 3.000 meters: 40 minutes 45 seconds.
Climb to 4.000 meters: 1 hour 30 minutes.

The Macchi Co. is building quite a number of these machines for distribution to the Italian squadrons for acrobatic and practice flying work.

Our Navy has recently purchased some of this type, which are at Anacostia. It is claimed that this type is very economical for keeping the pilots in flying trim.

The Macchi Co. is very well equipped to carry out flying boat construction and is specially noted for their hull construction. They are now constructing a number of *M-18* school flying boat type machines for the Italian Navy.

Characteristics of this machine are as follows:
Span: 15.80 meters.
Length: 9.75 meters.
Total height: 3.25 meters.
Motor, 6-cylinder Isotta: 250 horsepower.
Area: 45 square meters.
Weight, empty: 1,000 kilograms.
Useful load: 250 kilograms.
Total weight: 1,250 kilograms.

The useful load is made up as follows:
Pilot and student: 150 kilograms.
Fuel, 2½ hours: 95 kilograms.
Instruments: 5 kilograms.
Factor of safety: 10.
Maximum velocity: 160 kilometers per hour.
Minimum speed: 80 kilometers per hour.
Range: 350 kilometers.

MACCHI—M—15.

The Italian Army Air Service has recently ordered from the Macchi firm 12 M 15 two-place land machines for reconnaissance purposes. This is of the single-fuselage type, nose radiator, powered with Fiat A-12 bis, 300-horsepower engine, and with Warren truss wings.

Characteristics of this machine are as follows:
Span: 13.475 meters.
Length, over all: 8.570 meters.
Height: 3.300 meters.
Area: 42 square meters.
Weight, empty: 1,125 kilograms.
Useful load: 510 kilograms.
Total weight: 1,635 kilograms.

Load is made up as follows:
Pilot and observer: 150 kilograms.
Fuel for three hours: 225 kilograms.
Three machine guns: 45 kilograms.
Ammunition: 25 kilograms.
Photographic apparatus: 35 kilograms.
Radio and electrical installation: 25 kilograms.
Instruments: 5 kilograms.
Velocity: 200 kilometers per hour.
Factor of safety: 9.
Range: 600 kilometers.
Climb to 1,000 meters: 4 minutes, 40 seconds.
Climb to 2,000 meters: 10 minutes 45, seconds.
Climb to 3,000 meters: 19 minutes.
Climb to 4,000 meters: 30 minutes, 30 seconds.
Climb to 5,000 meters: 50 minutes.

This machine has not been executed in up-to-date fashion and does not represent the last word in construction. Accessibility, maintenance, and replacements on this type have not been very well thought out.

The Macchi firm has recently sold four of their old M-7 machines to Sweden.

THE ITALIAN SEAPLANE P. R. B. 1.

One of the most interesting seaplanes designed and built in Italy, representing a departure from the conventional, was the P. R. B. 1. It was designed by Mr. Pegna. It is a four-motored machine employing the Fiat 300-horsepower engine.

Principal characteristics are as follows:
Span: 3.40 meters.
Chord: 3.50 meters.
Gap: 4 meters.
Tail surface: 18 square meters.
Mobile surface: 6 square meters.
Total height: 6.60 meters.
Total length: 18 meters.
Width of hull, maximum: 2.81 meters.
Height of hull, maximum: 2.60 meters.
Length of wing floats: 3.50 meters.
Width of wing floats: 0.70 meter.
Height of wing floats: 0.70 meter.
Weight, empty: 5,200 kilograms.
Total weight: 8,200 kilograms.
Useful load: 3,000 kilograms.
Total horsepower: 1,040.
Weight per horsepower: 7.88 kilograms.
Weight per square meter: 39.61 kilograms.
Maximum speed, fully loaded: 170 kilometers per hour.
Economical speed: 150 kilometers per hour.
Landing speed: 80 kilometers per hour.

This machine is featured by its tandem Fiat engines mounted on the lower wing. They permit ready accessibility during flight or while on the water and the installation has permitted considerable cleaning up of the wings. It has none of the conventional type of supermotor structure.

The boat hull is constructed entirely of veneer with the usual concave bottom. The horizontal surfaces are adjustable during flight. Very close attention has been given in this job to streamlining wherever possible. Even the wire terminal fittings and fastenings are streamlined. Photographs of this machine are available at McCook Field.

This machine has considerable weight, but according to the designer it can be lightened in future jobs. It would be very well adapted for the installation of four Liberties without any appreciable increase in power plant weight inasmuch as the Fiat A-12, 300-horsepower engines weigh approximately the same as the Liberty 12 with 100 horsepower less.

This is the only four-motored seaplane built in Italy to date.

According to Mr. Pegna, setting the motors low on the wing did not give any trouble from water being sucked

up into the propeller zone, owing to the peculiar concave shape of the bottom of the boat. A chine guard base has been added, being attached on the bottom of the hull along the chine so as to neutralize as much as possible the chine wave spume. This spume is always evident with the V bottom type hulls.

The hull is entirely devoid of bulkhead construction and the internal bracing is effected by the addition of steel tubing. The bottom bracing from the step forward is of wood pieces, employing the Pratt truss. The ends of the rib stations use wires for their bracing.

The gasoline tanks are located on the upper wing. This is a radical departure from ordinary seaplane fuel tank adaptations and it minimizes the fire hazard to a marked degree.

The interpretation of this machine as a whole is a departure from the conventional with distinct advantages. The streamlining, accessibility, and very economical power plant mounting are commendable. The detail construction in the hull is to be criticized, but as a whole the general outlines and general arrangement of the machine are excellent.

FIAT PLANES AND MOTORS.

The Fiat Co. was one of the companies in Italy that had a huge amount of war stock on hand at the cessation of hostilities. They have attempted to dispose of this material to the best advantage and do a little development work at the same time. Their most interesting motors and machines are described below.

FIAT ENGINE TYPE A 12 BIS.

The characteristics of the famous Fiat A 12 bis, six-cylinder engine are as follows:

Power, maximum, at 1,700 revolutions per minute: 340 horsepower.
Power, average, at 1,600 revolutions per minute: 304 horsepower.
Power, guaranteed, at 1,600 revolutions per minute: 265 horsepower.
Normal speed: 1,700 revolutions per minute.
Maximum speed: 1,800 revolutions per minute.
Average speed of piston: 9.6 meters per second.
Number of cylinders: 6.
Cylinder bore: 160 millimeters.
Stroke: 180 millimeters.
Ratio of compression $\frac{V+v}{v}$: 4.7.
Average pressure: 7.6 eff. atmospheres.
Total weight, empty: 385 kilograms.
Total weight including water: 400 kilograms.
Approximative total weight with water and radiator: 442 kilograms.
Weight per horsepower with engine empty: 1.15 kilograms.
Weight per horsepower with water and radiator: 1.30 kilograms.
Petrol consumption per horsepower hour—
Guaranteed: 0.235 kilogram.
Average: 0.220 kilogram.
Oil consumption per horsepower hour—
Guaranteed: 0.025 kilogram.
Average: 0.015 kilogram.
Lubrication system: Forced feed.
Ignition system: 2 magnetos with 6 spark plugs.
Number of spark plugs for each cylinder: 2.
Number of valves per cylinder: 4.
Number of carburetors: 4.

Remarks.—The weights are to be allowed 5 per cent plus tolerance. The propeller is applied directly on the crank shaft with left-handed rotation and may be either tractor or pusher.

Further discussion of this engine is not necessary, as it is an old type and abundance of information is in our files.

FIAT A 14.

This motor is the famous 700-horsepower 12-cylinder Fiat engine which has been used with their B. R. and A. R. F. types of planes as well as their large passenger-carrying model. It is also used in the Fiat racer that Brack Papa flew in the French airplane cup race last year.

Power, maximum, at 1,700 revolutions per minute: 750 horsepower.
Power, average, at 1,650 revolutions per minute: 685 horsepower.
Power, guaranteed, at 1,650 revolutions per minute: 625 horsepower.
Normal speed: 1,650 revolutions per minute.
Maximum speed: 1,700 revolutions per minute.
Average speed of piston: 10.8 meters per second.
Number of cylinders: 12.
Stroke: 210 millimeters.
Cylinder bore: 170 millimeters.
Ratio of compressions $\frac{V+v}{v}$: 4.5.
Average pressure: 6.7 eff. atmospheres.
Total weight when empty: 730 kilograms.
Total weight including water: 760 kilograms.
Approximative total weight with water and radiator: 845 kilograms.
Weight per horsepower with engine empty: 0.970 kilogram.
Weight per horsepower with water and radiator: 1.13 kilograms.
Petrol consumption per horsepower hour—
Guaranteed: 0.235 kilogram.
Average: 0.220 kilogram.
Oil consumption per horsepower hour—
Guaranteed: 0.030 kilogram.
Average: 0.022 kilogram.
Lubrication system: forced feed.
Ignition system: 4 magnetos with 12 spark plugs.
Number of spark plugs for each cylinder: 4.
Number of valves per cylinder: 4.
Number of carburetors: 4.

Remarks.—The weights are to be allowed 5 per cent plus tolerance. The propeller is applied directly on the crank shaft with left-handed rotation and may be either tractor or pusher.

FIAT ENGINE A 15 R.

Fiat engine A 15 R, 400 horsepower, 12-cylinder, is of the geared-down type and is apparently very clean in appearance. Photographs of this motor will be found in our files.

Characteristics of this motor are as follows:

Power, normal: 400 horsepower.
Power, maximum: 425 horsepower.
Propeller, normal speed: 1,500 revolutions per minute.
Number of cylinders: 12.
Cylinder bore: 120 millimeters.
Stroke: 150 millimeters.
Ratio of compression, $\frac{V+v}{v}$: 5.5.
Average pressure: 7.7.
(Eff. atm. kg/cm.^{2}.)
Total weight when empty: 365 kilograms.
Total weight including water: 385 kilograms.
Approximative total weight with water and radiator: 410 kilograms.
Weight per horsepower with engine empty: 0.9 kilogram.
Weight per horsepower with water and radiator: 1.005 kilograms.
Petrol consumption per horsepower hour—
Guaranteed: 0.240 kilogram.
Average: 0.220 kilogram.
Oil consumption per horsepower hour—
Guaranteed: 0.025 kilogram.
Average: 0.012 kilogram.
Lubrication system: Forced feed.
Ignition system: 2 magnetos with 12 spark plugs.
Number of spark plugs per cylinder: 2.
Number of valves per cylinder: 4.
Number of carburetors: 4.

Remarks.—The weights are to be considered with 5 per cent plus tolerance. The propeller is applied on the speed-reducer shaft and its reduction ratio with the crank shaft is of 1:1.51.

The propeller rotation is left-handed and the propeller may be a tractor or a pusher.

The propeller shaft is drilled with with a hole 58 millimeters in diameter, through which can be fired a machine gun or cannon.

FIAT ENGINE A 18.

The Fiat engine A 18, 200 horsepower, nine-cylinder, water-cooled type, has the following characteristics:

Power, maximum, at 2,000 revolutions per minute: 320 horsepower.
Power, average, at 1,800 revolutions per minute: 300 horsepower.
Power, guaranteed, at 1,800 revolutions per minute: 300 horsepower.
Normal speed: 1,800 revolutions per minute.
Maximum speed: 2,000 revolutions per minute.
Cylinder bore: 130 millimeters.
Total weight when empty: 230 kilograms.
Average speed of piston: 9 meters per second.
Stroke: 150 millimeters.
Ratio of compression $\frac{V+v}{v}$: 5.5.
Average pressure: 7.7 eff/atmospheres.
Total weight including water: 248 kilograms.
Approximative total weight with water and radiator: 285 kilograms.
Weight per horsepower with engine empty: 0.72 kilogram.
Weight per horsepower, engine with water and radiator: 0.89 kilogram.
Petrol consumption per horsepower hour—
Guaranteed: 0.240 kilogram.
Average: 0.220 kilogram.
Oil consumption per horsepower hour—
Guaranteed: 0.030 kilogram.
Average: 0.020 kilogram.
Lubrication system: Forced feed.
Ignition system: 2 magnetos with 9 spark plugs.
Number of spark plugs for each cylinder: 2.
Number of valves per cylinder: 4.
Number of carburetors: 1.

Remarks.—The weights are to be allowed 5 per cent plus tolerance. The propeller is applied directly on the crank shaft with left-handed rotation and may be either tractor or pusher.

FIAT B. R.

This machine has the static factor of safety of 9, with an inclination of 25 per cent and with dissymmetric alternate loadings by 1 factor.

Characteristics are as follows:

Total weight of machine: 2,300 kilograms.
Useful load, including pilot, observer, armament, bombs, gas and oil: 1,000 kilograms.
(Although 1,200 kilograms have been carried.)
Total weight: 3,300 kilograms.
Normal load—
Equipment: 150 kilograms.
Armament: 45 kilograms.
Fuel for 3½ hours' flight, made up of—
Oil: 60 kilograms.
Gas: 370 kilograms.
Bombs: 370 kilograms.
Performance with useful load of 1,000 kilograms—
Speed at sea level: 253 kilometers per hour.
Speed at 1,000 meters: 245 kilometers per hour.
Speed at 2,000 meters: 241 kilometers per hour.
(The maximum speed attained by this machine at sea level has been up to 270 kilometers per hour; minimum, 99 kilometers per hour.)
Span of wings: 15.500 meters.
Total length: 9.820 meters.
Height: 3.800 meters.
Chord: 2.35 meters.

The B. R. is a monomotored plane with fuselage and cellule biplane semirigid. It was designed about the time the war ended for rapid, long-distance, day bombardment work. This machine, which has been used for many months by the Italians, has a static resistance and characteristics of flight which are remarkable.

Wing foil.—The lower left wing, in comparison with the right, is longer in order to correct the torque produced by the motor during flight.

(The transversal V for lateral stability is 2°.)

The upper planes are provided with compensated ailerons.

The gravity tank is placed in the center section. The mounting of the wings is of the semirigid type, with rigid uprights in the part nearest the fuselage and diagonals and counter-diagonal braces in the outer sections only. The wings are of conventional stick and wire construction.

Fuselage.—The fuselage has a mixed structure of wood (longerons, uprights, crosspieces) and steel (outer supports, motor support, foot supports, etc.). The covering is of wood veneer except the lower part, which is covered with linen. The section is almost entirely rectangular. The forward part of the longerons are of oak, the back part of spruce.

The motor supports are of soft sheet steel.

The disposition which is successively encountered is: Propeller, radiator, motor, under which is placed the oil-tank furnished with a radiator situated below the lower surface of the fuselage, vertical bomb rack, pressure gas tanks, pilots' seat, observer's seat furnished with a machine gun for firing toward the rear, bottle of compressed air for starting the motor, and the empennage.

Empennage.—The empennage comprises a fixed fin, a horizontal stabilizer, fixed, and a compensated rudder and elevator. All the structure of the empennage is of wood with the exception of the bearing axes, the hinges, and the control levers.

Motor apparatus.—The motor apparatus comprises: One aviation motor, Fiat A-14, 700 horsepower, 1,650 revolutions per minute.

Bomb rack.—The airplane is furnished with two bomb racks, a vertical one in the fuselage with a capacity of three bombs, 280 millimeters, 25 kilograms each; and a bomb rack placed upon the lower wing for six "Batignolle" bombs, three on each side of the fuselage.

FIAT C. R.

The Fiat Co. has recently laid out a new single-seater pursuit airplane around the 300 horsepower engine. This machine has the Warren truss type wing structure that is ordinarily characteristic of most Italian jobs. The fuselage construction is practically the same as the BR, which has been described.

This machine is equipped with a nose radiator. It has not been built to date, but the Fiat Co. hopes to build it very soon for the Italian Air Service, which has on hand 2,000 300-horsepower Hispano engines which they intend to use very shortly in their new program in equipping all their future pursuit planes. The description of this machine is as follows:

Manufacturers' description—cellule.—The cellule is biplane and the two surface planes are joined together by an entirely rigid structure which assures a high static resistance, indeformability, and a lower head resistance than that obtained with other cellules of ordinary type.

Because of the special system of rigid mounting adopted, the lower wing is longer than the upper. The ailerons are actuated by a rigid tube control. Little universal joints are applied in the control tube in order to render control easier even during acrobatic evolutions.

The longer lower wing has also the advantage of lowering the center of gravity of the machine, bringing it nearer to the center of surface pressure (generally high), in a manner which assures easy guidance of the machine in all directions. It seems, besides, that the longer lower wing assures a better control in flights near the ground, which naturally facilitates landing.

The triangular Warren trusswork adopted is an advantage in not being subjected to initial tensions of any sort, and it is unaffected by variations of temperature for its predetermined gap incidence, etc. This characteristic is important in consideration of the considerable discrepancy caused by these variations at the high altitudes at which pursuit planes operate. The completely rigid system, once well regulated, eliminates the series of continual revisions exacted by cellules with diagonals.

Disassembly and assembly of the cellule are also easier. The focusing of the incidence of the surface planes for lateral equilibrium is possible by means of transversal crosspieces among the extreme uprights, and variations of incidence are generally small and can be obtained without the use of special attachments at the ends of the struts. Both top and lower planes have 1° dihedral.

With regard to construction material, they have preserved the old tradition of the mixed system, which still seems to respond to fundamental demands of economy, lightness, resistance, lasting qualities, and ease of construction.

Fuselage and accessories.—The fuselage also has a mixed construction of wood (longerons, uprights, etc.) and metal (diagonals, fitting plates, motor mounting, different installations, etc.). The covering is of veneer wood construction. The maximum length of the fuselage from the outer face of the radiator to the extremity of the tail is about 5 meters, while the maximum width in the principal sections is about 85 centimeters.

In the forward part of the fuselage is the motor mounting made of sheet-steel supports to facilitate easy mounting and demounting of the motor.

The machine is furnished with an oil radiator automatically controlled.

The two machine guns are placed between the two vees of cylinders of the motor and have a mechanical synchronization gear. Their proximity to the pilot assures easy maneuverability of the lever which controls the extractor.

The wind shield is placed so as to render aiming of the guns comfortable for the pilot and assures him perfect visibility either for combat or for landing.

The gas tank (for the time being a pressure tank), placed beneath the pilot, is provided with an ample release mechanism controlled by the pilot, which permits him to free himself of gasoline very rapidly in case of fire.

They have begun the study of a landing gear with steel springs and they hope that it will be superior to the ordinary "sandow" suspensions.

Control surfaces.—They have, with the application of the ailerons in the lower wings, realized the end of having all the control surfaces easy to be inspected even in the most delicate parts of the hinges.

The rigid control obtained for the ailerons obviates the use of cables. For the elevating planes and the rudder, cable controls are provided.

Motor.—The motor applied in this airplane is the Hispano-Suiza 300 horsepower.

Static characteristics.—The coefficient of safety of the machine, in hardest conditions with a load, is about 12½, a figure estimated to be more than sufficient for the most perilous conditions conciliable with the physical resistance of the pilot.

This coefficient has been calculated with a latitude of 2 coefficients more than would be necessary for the absolute safety of the pursuit airplane.

Characteristics:

Weight of airplane, empty: 740 kilograms.

(Gas, 150 kilograms.)

Useful load: 310 kilograms.

(Oil, 25 kilograms; pilot, 75 kilograms; arms, 60 kilograms.)

Weight of plane, fully loaded: 1,050 kilograms.

Maximum wing span: 8.85 meters.

Maximum length: 5.75 meters.

Height: 2.45 meters.

Chord: 1.45 meters.

Plane surface: 22 square meters.

Load per square meter: 47.7 kilograms.

Weight per horsepower: 3.5 kilograms.

Horsepower per square meter: 13.6.

Motor, Hispano-Suiza: 300 horsepower.

Estimated performance characteristics are as follows:

Speed at ground: 270 kilometers per hour.

Speed at 5,000 meters: 260 kilometers per hour.

Climb to 5,000 meters: 15 minutes.

Climb to 6,000 meters: 22 minutes.

Climb to 7,000 meters: 32 minutes.

FIAT RACER.

The Fiat racer is powered with a 700-horsepower Fiat engine.

From all outward appearances it is very conventional in layout and is of the characteristic Fiat type of construction. The only marked departure lies in the radiator installation, which is of the vertical fin type and extends out from the fuselage in the trailing edge of the lower wing.

This machine holds a record of speed on a 100-kilometer course.

The exhaust pipes are so constructed as to give them the least resistance in flight possible. The load factor of safety for the wings is 15. The gasoline tank is located between the pilot and the engine and carries sufficient gas for one and one-half hours' flight.

The tail planes are along the same lines as in the B. R.

The load per square meter is approximately 65 kilograms.

This machine attained a velocity of 299 kilometers per hour when flying over the circuit in the race in France.

The company is now completing two other machines of this type and states that they intend to develop a new type of reconnaissance plane and equip it with an A 12 bis, 300-horsepower Fiat engine.

Factor of safety: 12.

Twenty-five per cent inclination with C. P. 31 to 40 per cent of chord.

Area: 33 square meters.

Diameter of propeller: 3.30 meters.

Total weight: 2,150 kilograms.

Load per square meter: 62 kilograms.

Pitch: 3.40 meters.

Load per horsepower: 3.10 kilograms.

Revolutions per minute: 1,500.

FIAT A. R. S.

The Fiat Co. has designed a two-seater pursuit plane with a 300-horsepower Hispano engine. It has the conventional Fiat wing and truss, nose radiator installation, and characteristic Fiat detailed construction throughout. The upper wing, however, is shorter than the lower wing, and ailerons are fitted to the bottom wings only. The pilot is seated between the two wings and directly beneath the upper wing. This makes the visibility overhead very bad. The gasoline tank is situated underneath the pilot.

This machine was designed to fulfill the specifications for a two-seater fighter as prescribed in the Italian program.

FIAT A. R. F.

Characteristics are as follows:

Total weight: 4,700 kilograms.

Weight, empty: 2,350 kilograms.

Useful load: 200 kilograms.

Gas: 1,850 kilograms.

Oil: 300 kilograms.

Span of wings: 16.23 meters.

Length: 10.126 meters.

Height: 3.700 meters.

Speed: 250 kilometers per hour.

Flight endurance: 18 hours.

Motor, Fiat: 700 horsepower.

This machine is practically a modification of the famous Fiat B. R. and was made for trans-Atlantic flight or for long-distance flight of any nature up to about 18 hours. This machine is very sturdy and is characterized principally by its robust structure in its entirety.

The ailerons have the paddle counterbalancing feature. The fuselage is of the veneer and wire truss type of construction.

FIAT TWELVE-PASSENGER AIRPLANE.

The Fiat Co. has also designed and constructed another interesting type for carrying passengers. It is known as the Fiat 12-passenger airplane. This machine has been fully described in periodicals and complete description was procured for our engineering division.

It is geometrically similar to the Fiat B. R. in its principal outlying characteristics and detailed design. It has the following dimensions and characteristics:

Weight, empty: 3,200 kilograms.

Fuel and oil: 750 kilograms.

Instruments and wireless equipment: 50 kilograms.

Personnel: 150 kilograms.

Total weight: 5,000 kilograms.

Passengers: 850 kilograms.

Motor: 700 horsepower.

Surface area: 125 square meters.

Factor of safety: 8.

Normal flight endurance: 6 hours.

Maximum flight endurance: 6 hours.

FIAT AUTOMATIC CANNON.

Diameter, 25 millimeters.

Complete description of this 26-millimeter cannon is set forth in the Fiat descriptive catalogue which has been mailed to the Air Service Engineering Division.

It is now undergoing exhaustive tests by the Italian Air Service.

Characteristics:

Weight of gun: 45 kilograms.
Weight of projectile: 200 grams.
Weight of charge: 12.5 grams.
Initial velocity: 440 meters per second.
(At mouth of gun.)
Pressure in breech: 2,000 atmospheres.
Rate of fire: 8 rounds per 2 seconds.
Maximum range: 4,000 meters.
Weight of shell container, empty: 1.85 kilograms.
Weight of shell container, full: 4.45 kilograms.

THE CAPRONI CO.

The Caproni Co. is probably the best known aeronautical company in Italy. Mr. Caproni, the head of the firm, is the chief designer as well as the owner of the entire plant. The Caproni factory is located at Taliedo, about 3½ miles out of Milan. It has excellent connections with the city by both steam and electric lines. The plant is large and well equipped for the production of airplanes in great quantities. However, at the present time no work is being done on airplanes and the entire energy of the plant is being devoted to the manufacture of railway cars.

The Caproni Co. has suffered severe financial losses since the war due to the sharp curtailment of orders that were on hand, the failure of the great tandem triplane, and the seizure of the factory by Bolsheviks. During the last winter the shortage of electrical power, caused by the failure of ample rainfall in the Alps, forced rationing of current, and the Caproni plant could operate only three days in the week, and this has tended to further cripple Caproni.

However, he has gone steadily ahead with his work and has design for three new types. He desires to construct a new seaplane and a new airplane, each equipped with four engines, and to again try out his great tandem triplane seaplane.

The Caproni triplane seaplane which failed was one of the most daring attempts ever made in aeronautics. Mr. Caproni carried out extensive experiments with this new tandem triplane at a cost of 3,500,000 lire. This represented practically his entire fortune. Interest in aviation had lagged to such an extent that an ordinary success would not have been sufficient to put him on his feet, so he determined on this radical venture, feeling assured that if he succeeded in flying the triplane and in carrying a tremendous load that it would be sufficient to open a new era in type construction. He believed that he could utilize the planes that had been built for his triplanes during the war and intended to stagger them in such a way that the air flow from the leading planes could be utilized to generate lift under the lower surfaces of the planes behind.

His experimental work was necessarily more or less meager and slipshod, inasmuch as the greatest secrecy was maintained and the officials of the Italian Experimental Station could not be called in without divulging the nature of the work. He was so sure of success that he continued without governmental assistance until the machine was almost completed.

His system of controls, position of planes, methods of construction, and many other features appeared to be quite sound and the machine actually flew. Mr. Caproni attributes the loss of the machine to the inability of the pilot to understand the principles of the moment of inertia. The engine was stalled and the machine dropped into the water with terrific force, breaking the hull. Mr. Caproni believes that had the plane been left where it was that there were sufficient air-tight compartments to sustain it until repairs could be made, but the pilot attempted to taxi the machine, which forced water into the hull, causing the plane to sink, which damaged it to such an extent that repairs were impossible.

Mr. Caproni still believes that the theory of this type of construction is correct, and he intends to go ahead and construct another plane of the same type, which will be much smaller. He intends this to be able to carry about 50 tons. He is receiving some financial assistance from the Italian Government, and it is hoped that he may be able to carry out these experiments in order to determine the relative value of this idea.

The Caproni Co. has transformed a considerable number of their old triplanes into transports. These are all more or less mediocre, of the old conventional orthodox construction. Caproni does not seem to be able to depart from the stick and wood construction with its incident head resistance. However, he is gradually cleaning up his machines.

He has designed a new three-motored machine with twin fuselages and center nacelle. The motor mountings are quite similar to his previous types. This machine has a wide track landing gear very similar to the gear on the American Martins. There is nothing remarkable about the machine, but it is indicative of a slight change in the Caproni types. It is interesting to note that Mr. Caproni built the first successful bimotored ships and has continued to build them almost identical with his first job up to the present day, while his competitors have usurped his ideas and have developed them far beyond anything conceived by Caproni.

The characteristics of his new machines are:

Total weight: 4,100 kilograms.
Useful load: 1,800 kilograms.
Speed: 100 meters per hour.
Ceiling: 3,000 meters.
Power, Isottas: 380 horsepower.
Fuel for four hours.
Crew: 3 men.
Load: 1 ton of bombs.

Three view drawings of this latest machine have been forwarded to the engineering division. This machine is also being studied with a view to equipping it with 300-horsepower engines, and it is quite probable that a small number of these ships will be ordered by the Italian Government for night bombardment work.

To summarize the work of Caproni, one can state that he is still adhering to his stick and wire construction. His ships still have the great head resistance incidental to his type of plane and have no departures in design or in performance. His one possible contribution at the present time may be with the tandem triplane. Not much hope is held out for a sensational success with this particular machine, but it may be the means of procuring a great deal of valuable information as to the utilization of the energy in disturbed air.

THE ANSALDO COMPANY.

The Ansaldo Co. is one of the most active aeronautical concerns in Italy. They are busy constructing several machines for Italy and have negotiated good foreign sales which are directly in line with their desires to build not only for military purposes but to establish commercial markets as well.

Machines of the A-300 C type and of the Balilla type have been sold to Belgium. Spain has purchased 30 of the A-300 type for reconnaissance work and training. Spain is also negotiating at the present time for the purchase of some of the Balilla type. Rumania and Poland have bought some of the A-300 type. Some of the South American Republics, including Ecuador and Peru, are negotiating for some of the S. V. A. and A-300 type.

New types are constantly being constructed by this company, the object being to increase the ultimate performance and the weight carrying per horsepower, but utilizing for the present part of the large stock of left-over war motors of the Fiat, Isotta, and Spa types.

Ansaldo A 300-4.

The most notable Italian military type is the Ansaldo A 300-4 type. This machine is a biplane with a 300-horsepower Fiat engine. The fuselage is entirely constructed of wood with spruce longerons and veneer covering and has a triangular aft fuselage section.

The wings are of the two-bay type. The wing spars are built of two longerons, box-shaped type, covered with linen. The upper wing is fastened to the body by a W-shaped set of center section struts.

The landing gear is entirely of metal with rubber shock absorbers.

The armament consists of two machines guns which are synchronized to the motor, and one movable gun on the observer's tourelle.

The cooling system is of the French Lamblin type.

Characteristics of this machine are as follows:

Over-all length: 8.60 meters.
Height: 2.980 meters.
Span: 11.640 meters.
Total area: 41 square meters.
Load per square meter: 40.800 kilograms.
Load per horsepower: 5.58 kilograms.
Fiat motor, A 12 bis: 300 horsepower.
Weight, empty: 1,225 kilograms.
Useful load: 450 kilograms.
Military load: 150 kilograms.
Total weight: 1,825 kilograms.

The load is made up as follows:

Pilot: 75 kilograms.
Observer: 75 kilograms.
Instruments: 10 kilograms.
Photographic apparatus: 25 kilograms.
Machine gun: 30 kilograms.
Cartridges: 10 kilograms.
Gasoline: 245 kilograms.
Oil: 30 kilograms.
Bombs: 100 kilograms.
Total useful load: 600 kilograms.
Speed at sea level: 200 kilometers per hour.
Speed at 1,000 meters: 195 kilometers per hour.
Climb to 1,000 meters: 7 minutes 20 seconds.
Climb to 2,000 meters: 10 minutes 20 seconds.
Climb to 3,000 meters: 17 minutes 55 seconds.
Climb to 4,000 meters: 26 minutes 10 seconds.
Climb to 5,000 meters: 37 minutes 41 seconds.
Ceiling: 7,000 meters.
Load factor of safety of the wings: 8½.
Load factor of the fuselage: 15.

This machine with the Fiat two-place job represents the best existing Italian two-seaters, and the main reason the performance is not remarkable is that the Fiat engine is very heavy and underpowered for its weight. This machine would have a remarkable performance if it had a power plant installation analogous to our Liberty 12.

ANSALDO SCHOOL MACHINE.

The Ansaldo Co. is completing the construction of a school airplane. The upper and lower wings have the same dimensions. There are ailerons on the lower wings only, as in the A-200 and the A-250 types. The wings and struts are interchangeable. The landing gear is the usual S. V. A. type, but much stronger. It is being equipped with a Colombo 110-horsepower engine. This motor is very heavy, weighing approximately 3 pounds per horsepower.

The radiator, of the Lamblin type, is capable of being shuttered in flight and placed in the undercarriage struts. This machine is fitted with dual control. The fuselage is of the conventional stick and wire construction.

ANSALDO A-200 AIRPLANE.

This is a single-seater and was especially constructed for the races at Brescia. The secondary purpose was to experiment with a new type pursuit airplane. Due to the lack of time before the races, an S. V. A. fuselage was used. Tail surfaces were slightly changed and were similar to the Balilla type. The undercarriage is that of the S. V. A.

Total supporting surface of 15 square meters with a load of 59 kilograms per square meter. The engine is a normal 200-horsepower S. V. A. High speed is 249 kilometers per hour. Ailerons are on the bottom wing. A special fuselage is being built for this machine at present, and when completed this machine will be turned over to the air service experimental section for tests.

ANSALDO 250-HORSEPOWER, A-250 AIRPLANE.

This machine is similar to the A-200 except that it has a slightly increased supporting area and is equipped with an Isotta six-cylinder, 250-horsepower engine. High speed is 248 kilometers per hour.

THE BREDA CO.

The Breda Co. has a wonderful plane located in the outskirts of Milan. This company is perhaps one of the most wonderful manufacturing industries in Italy. They produce everything that can be made from metal. Their principal production at the present time is electric locomotives. The Breda Co. is the General Electric Co. of Italy.

During the war they turned their attention to aeronautics and established a division of their company to produce

aircraft. Their principal work during this period was the construction of Caproni planes. They succeeded in cleaning up the Caproni and reduced the head resistance to a great extent, but the machine was still the Caproni type and the Breda Co. made no radical departures from the conventional design.

A large force of Austrian prisoners were impressed into the service of the Breda Co. and were forced to construct a really wonderful airdrome. Twelve large, roomy, well-lighted concrete and steel hangers were constructed in two groups of six each. The airdrome in front of these hangars is as smooth as a carpet and large enough for any experimental work they may choose to do.

At the time of inspection these hangars were practically empty. A certain amount of aeronautical equipment was being stored for the Italian Government. This consisted mostly of motors.

The Breda Co. is attempting to hold their little aeronautical nucleus together, although they have no substantial orders at the present time to warrant expenditures. Their aeronautical engineers do not appear to be particularly talented. Nothing apart from the conventional was found in their factory. About four different designs of sporting types of planes were being constructed and tested. These were all very small, using rotary engines from 160 to 220 horsepower.

They had converted a Caproni plane into a transport, but the improvements were not sufficient to warrant its production. They have committed the usual error of putting part of the passenger compartment ahead of the motors and leaving the gas tanks inside. This type of construction will never do for transport work as it is not conducive to the safety of the passengers in case of a crash.

The Breda Co. reports that they are constructing a new six-cylinder radial engine. It is supposed to develop 100 horsepower and to weigh approximately 250 pounds. Characteristic data on this motor could not be obtained. They also report that they are working on a 300-horsepower engine and have orders to construct several of these for official test in the near future. The principal improvements claimed for this 300-horsepower motor are that it will be lighter than the Fiat 300 A 12 type and will have a smaller fuel consumption.

The Breda Co. has done some experimental work with the problem of gearing two motors to a single propeller. No reliable information could be obtained, but according to their claims it has undergone successful tests which will warrant continuing its development.

The Breda firm as it stands to-day is not particularly interesting from an aeronautical viewpoint, but is a powerful, potential factor should necessity arise requiring rapid production of aircraft in Italy. Such facilities as are available and the trained force on hand would enable the Breda Co. to quickly expand and turn out large numbers of aircraft.

TARGET AIRPLANE.

The Italians have designed a very interesting and very practicable target airplane that can be constructed at a small cost. This is a monoplane of stick and wire construction with a wing area of about 6 square meters. Its total weight is about 30 kilograms.

It is provided with an automatic control for maintaining its direction and the tail plane can be set for any angle of glide that is desired. Instead of a landing gear it has a landing skid which is so bent over, under, and around the glider that when it comes in contact with the ground it can roll over and over without damage. The skid goes over the tail surface as well to protect it.

This target airplane can be dropped from an airplane or airship and provides an excellent opportunity for target practice from airplanes. These machines could be built cheaply and would afford an excellent means of keeping up aerial marksmanship.

GERMANY.

RÉSUMÉ OF GERMAN RESEARCH DEVELOPMENT IN AIRCRAFT CONSTRUCTION.

The treaty of Versailles gave the Allies the power to regulate the construction of aircraft in Germany. The allied powers issued an ultimatum on May 5, 1921, compelling the German Government to publish a law prohibiting all aircraft construction in Germany. This law is being carefully observed by all aircraft manufacturers and no new aircraft have been constructed since about July 1, 1921. However, on May 5, 1922, a certain leniency will be shown by the Allies toward German aircraft manufacturers to allow construction to take place on commercial types, limited in horsepower and in scope of possible interchangeability features that might render them convertible into military types.

Under the treaty of Versailles, Germany is prohibited from the manufacture and export of any war material; consequently there has been no new development in Germany since the end of the war.

The difficulty encountered in Germany in welding duralumin parts and fittings has not been overcome. The three leading German firms which have used duralumin in aircraft construction are the Junker Co., the Zeppelin Co., and the Shuttelanz Co. All the constructors agreed that riveting processes are not economical from a manufacturing standpoint, and continued research toward eliminating this method is being maintained.

The Lachmann air foil data, which is analogous to the famous Handley-Page type, is now being translated by the Berlin air attache's office and will be forwarded when completed.

The only adjustable pitch propellers designed in Germany have been designed and constructed by the Helix Maschinenbau Co., Berlin. These propellers are constructed under patents belonging to Doctor Reissner. The latest develpments in the adjustable pitch propeller are embodied in a sample propeller which was sent to the N. A. C. A., Washington, D. C., in October, 1921. Due to the prohibition against aircraft construction of all kinds in Germany, no adjustable pitch propellers of the latest type designed by the Helix Co. have been put into service. The last practicable service use in Germany of the Reissner adjustable pitch propeller was in 1918, when two of this type were used on the R-30, a Staaken giant airplane. They received about a six months' service test.

Four Haw propellers were used during the summer of 1921 on airplanes of the Ostflug Co., operating an air mail and passenger service between Berlin and Konigsberg, East Prussia. A few other Haw propellers, probably not more than 10, have been used in test flights by the five other air traffic companies operating in Germany during the past year.

The best German bomb sights developed during the war were designed and produced by the C. P. Goerz Optical Co., of Berlin. Numerous reports on their production and characteristics, however, have been received by our Air Service, and Mr. Spahn was in America during 1921, and is now in the States again for the specific purpose of discussing the taking over by our Government of the Goerz bomb sights and patents.

One of the best aircraft machine guns produced in Germany during the war was the Gast double-barreled type. This gun was turned over to the ordnance officer, American Forces in Germany, Coblenz, in December, 1921, for shipment to the Chief of Ordnance, Washington, D. C.

With respect to the subjects of magnesia alloys, cooling systems, power plants, fuel systems, superchargers, radio, airdrome illumination, oxygen apparatus, navigation instruments, photographic materials, methods of designing for controllability and stability, and data on methods which have been used by Doctor Parndtl, all have been obtained in publications or treatises in German, which are now being translated by our military attache's office in Berlin and will be forwarded as soon as possible.

ZEPPELIN AIRSHIPS.

The Zeppelin lighter-than-air main plant is located at Friedrichshafen. The main Zeppelin Co. is not at present engaged in the manufacture of any lighter-than-air equipment. This information was procured from Doctor Eckner and Mr. Dorr, the directors of the Zeppelin Co. Mr. Dorr has been chief designer and engineer of the Zeppelin Co. for 22 years. The company has a very small operating organization at present, principally made up of the heads of departments. One building has been entirely given over to museum purposes, where all the successive stages of Zeppelin experimentation, designs, and models of power-plant installation in Zeppelin units are assembled in operating fashion, so as to demonstrate to interested parties peculiar functions of clutches and pertinent units of power-plant installation. The directors are very much concerned over the possibility of receiving an order from the United States Navy for a large Navy type Zeppelin, but realize that negotiations for the construction of this ship will probably be drawn out for a long time.

Doctor Eckner claims that semirigids are more efficient in small sizes than in large sizes, but that the dirigibles are far superior for larger weight-carrying types. He gives the following comparisons:

PARSEVAL.	ZEPPELIN.
32,000 cubic meters: 20 metric tons.	32,000 cubic meters: 17 metric tons (useful load).
56,000 cubic meters: 35 metric tons (estimated).	56,000 cubic meters: 39½ metric tons.

Relative data on Zeppelin airship for the United States and last German naval type:

	L-2114, GERMAN NAVAL TYPE.	PROPOSED U. S. NAVY SHIP.
Greatest length	226.5 meters	206 meters.
Greatest diameter	23.9 meters	27.9 meters.
Greatest height	27.8 meters	31 meters.
Greatest breadth	23.9 meters	28 meters.
Gas content	68,500 cubic meters	68,000 cubic meters.
Power per engine	240 horsepower	400 horsepower.
Number of engines	6	5.
Total power	1,440 horsepower	2,000 horsepower.
Maximum velocity	32 meters per second	36 meters per second.
Weight, empty	32 metric tons	35 metric tons.
Useful load	47½ metric tons	46½ metric tons (which depends on U. S. requirements of strength desired). Cabin for 30 persons with sleeping quarters.

Below are given charts and explanatory data from Doctor Eckner relative to the comparison of airships and the use of nondimensional characteristics.

The characteristic data of all the different Zeppelin models, from their first model to the last war-time model, giving their construction number, where built, name or mark, whose property, capacity in cubic meters, and all data relative to Zeppelin accidents also follows.

Construction No.	Number of compartments.	Length.	Diameter.	Carrying power at 0.76 millimeter.	Number of motors.	Horsepower of each motor.	Total horsepower.
		Meters.	*Meters.*	*Kilograms.*			
LZ-1	17	128	11.65	....	2	14.7	29
LZ-2	16	128	11.65	[1] 2,700	2	85	170
LZ-3	16	128	11.65	[1] 2,700	2	85	170
	17	136	11.65	[1] 2,700	2	100	200
LZ-4	17	136	13	[1] 4,500	2	100	200
LZ-5	17	136	13	[1] 4,500	2	100	200
	17	136	13	[1] 4,500	2	115	230
LZ-6	18	144	13	[1] 4,000	3	2 of 115 1 of 140	370
LZ-7	18	148	14	[1] 6,500	3	120	360
LZ-8	18	148	14	[1] 6,500	3	120	360
LZ-9	16	132	14	....	3	140	420
	17	140	14	[1] 6,000	3	140	420
LZ-10	17	140	14	[1] 6,000	3	140	420
LZ-11	18	148	14	[1] 6,200	3	140	420
LZ-12	17	140	14	[1] 6,000	3	140	420
LZ-13	18	148	14	[1] 6,200	3	165	495
LZ-14	18	158	14.86	[1] 8,600	3	165	495
LZ-15	16	142	14.86	[1] 7,050	3	165	495
LZ-16	16	142	14.86	[1] 7,000	3	165	495
LZ-17	16	140	14.86	[1] 7,000	3	165	495
	17	148	14.86	[1] 7,500	3	165	495
LZ-18	18	158	16.6	[1] 11,000	4	165	660
LZ-19	16	140	14.86	[1] 7,000	3	165	496
LZ-20	16	140	14.86	[1] 7,000	3	165	495
	17	148	14.86	[1] 7,400	3	165	495
LZ-21	17	148	14.86	7,500	3	165	495
LZ-22	18	156	14.86	8,000	3	175	525
LZ-23	18	156	14.86	8,000	3	175	525
LZ-24	18	158	14.86	8,700	3	210	630
LZ-25	18	158	14.86	8,700	3	210	630
LZ-26	15	161.2	16	11,000	3	210	360
LZ-27	18	158	14.86	8,700	3	210	360
LZ-28	18	158	14.86	8,700	3	210	360
LZ-29	18	158	14.86	8,700	3	210	360
LZ-30	18	158	14.86	8,700	3	210	360
LZ-31	18	158	14.86	8,700	3	210	360
LZ-32	18	158	14.86	8,700	3	210	360
LZ-33	18	158	14.86	8,700	3	210	360
LZ-34	18	158	14.86	8,700	3	210	360
LZ-35	18	158	14.86	8,700	3	210	360
LZ-36	15	161.4	16	10,000	3	210	360
LZ-37	18	158	14.86	8,700	3	210	630
LZ-38	15	163.5	18.7	15,000	4	210	840
LZ-39	15	161.4	16	[2] 10,000	3	210	630
LZ-40	16	163.5	18.7	[2] 15,000	4	210	840
LZ-41	16	163.5	18.7	15,000	4	210	840
LZ-42	16	163.5	18.7	15,000	4	210	840
LZ-43	16	163.5	18.7	15,000	4	210	840
LZ-44	16	163.5	18.7	15,000	4	210	840
LZ-45	16	163.5	18.7	15,000	4	210	840
LZ-46	16	163.5	18.7	15,000	4	210	840
LZ-47	16	163.5	18.7	15,000	3	210	870
					1	240	
LZ-48	16	163.5	18.7	15,000	4	240	960
LZ-49	16	163.5	18.7	15,000	4	210	840
LZ-50	16	163.5	18.7	[1] 15,000	4	240	960
LZ-51	16	163.5	18.7	15,000	4	240	960
	18	178.5	18.7	17,500	4	240	960
LZ-52	16	163.5	18.7	15,000	4	240	960
LZ-53	16	163.5	18.7	15,000	4	240	960
LZ-54	16	163.5	18.7	15,000	4	240	960
LZ-55	16	163.5	18.7	15,000	4	210	840
LZ-56	16	163.5	18.7	15,000	4	210	840
	18	178.5	18.7	17,500	4	210	840

[1] About. [2] Recorded.

Construction No.	Number of compartments.	Length.	Diameter.	Carrying power at 0.76 millimeter.	Number of motors.	Horsepower of each motor.	Total horsepower.
		Meters.	*Meters.*	*Kilograms.*			
LZ-57	16	163.5	18.7	[1] 15,000	4	240	960
	18	178.5	18.7	17,500	4	240	960
LZ-58	16	163.5	18.7	15,000	4	210	840
	18	178.5	18.7	17,500	4	240	960
LZ-59	18	178.5	18.7	17,500	4	240	960
LZ-60	16	163.5	18.7	15,000	4	240	960
	18	178.5	18.7	17,500	4	240	960
LZ-61	18	178.5	18.7	17,500	4	240	960
LZ-62	19	198	23.9	28,700	6	240	1,440
LZ-63	16	163.5	18.7	15,000	4	210	840
	18	178.5	18.7	17,500	4	240	960
LZ-64	18	178.5	18.7	17,500	4	240	960
LZ-65	18	178.5	18.7	17,500	4	240	960
LZ-66	18	178.5	18.7	17,500	4	240	960
LZ-67	18	178.5	18.7	17,500	4	240	960
LZ-68	18	178.5	18.7	17,500	4	240	960
LZ-69	18	178.5	18.7	17,500	4	240	960
LZ-70 [3]	...	...	...	...	...	...	...
LZ-71	18	178.5	18.7	17,500	4	240	960
LZ-72	19	198	23.9	30,000	6	240	1,440
LZ-73	18	178.5	18.7	17,500	4	240	960
LZ-74	19	198	23.9	[1] 30,000	6	240	1,440
LZ-75	19	198	23.9	[1] 30,000	6	240	1,440
LZ-76	19	198	23.9	[1] 30,000	6	240	1,440
LZ-77	18	178.5	18.7	17,500	4	240	960
LZ-78	19	198	23.9	[1] 31,000	6	240	1,440
LZ-79	19	198	23.9	[1] 31,000	6	240	1,440
LZ-80	19	198	23.9	[1] 31,000	6	240	1,440
LZ-81	18	178.5	18.7	17,500	4	240	960
LZ-82	19	198	23.9	32,000	6	240	1,440
LZ-83	19	198	23.9	32,000-32,500	6	240	1,440
LZ-84	19	198	23.9	32,000-32,500	6	240	1,440
LZ-85	19	198	23.9	32,000-32,500	6	240	1,440
LZ-86	19	198	23.9	32,000-32,500	6	240	1,440
LZ-87	19	198	23.9	32,000-32,500	6	240	1,440
LZ-88	19	198	23.9	32,000-32,500	6	240	1,440
LZ-89	19	198	23.9	32,000-32,500	6	240	1,440
LZ-90	19	198	23.9	32,000-32,500	6	240	1,440
LZ-91	18	196.5	23.9	36,000	5	240	1,200
LZ-92	18	196.5	23.9	36,000	5	240	1,200
LZ-93	18	196.5	23.9	37,500	5	240	1,200
LZ-94	18	196.5	23.9	37,500	5	240	1,200
LZ-95	18	196.5	23.9	39,000	5	240	1,200
LZ-96	18	196.5	23.9	39,000	5	240	1,200
LZ-97	18	196.5	23.9	39,000	5	240	1,200
LZ-98	18	196.5	23.9	39,000	5	240	1,200
LZ-99	18	196.5	23.9	39,000	5	240	1,200
LZ-100	14	196.5	23.9	40,000	5	240	1,200
LZ-101	14	196.5	23.9	40,000	5	240	1,200
LZ-102	16	226.5	23.9	52,000	5	240	1,200
LZ-103	14	196.5	23.9	40,000	5	240	1,200
LZ-104	16	226.5	23.9	52,000	5	240	1,200
LZ-105	14	196.5	23.9	40,000	5	290	1,450
LZ-106	14	196.5	23.9	40,000	5	290	1,450
LZ-107	14	196.5	23.9	40,000	5	290	1,450
LZ-108	14	196.5	23.9	40,000	5	290	1,450
LZ-109	14	196.5	23.9	40,000	5	290	1,450
LZ-110	14	196.5	23.9	40,000	5	290	1,450
LZ-111	14	196.5	23.9	40,000	5	290	1,450
LZ-112	15	211.3	23.9	[1] 40,000	7	290	2,030
LZ-113	15	211.5	23.9	[1] 40,000	7	290	2,030
LZ-114	15	211.5	23.9	[1] 40,000	7	290	2,030
LZ-115-LZ-119, inclusive [4]	...	...	...	...	...	...	...
LZ-120	12	130	18.7	11,500	4	240	960
LZ-121	...	130	18.7	11,500	4	240	960

[1] About. [3] Construction suspended to clear yard for the LZ-71. [4] Not built.

Construction No.	Where built.	Name or mark.	Property of—	Capacity in cubic meters.
LZ-1	Manzell		Zepplin Co.	11,300
LZ-2	do.		do.	11,300
LZ-3	do.		do.	11,300
		Z I [1]	Military board	12,200
		Z I [2]	do.	12,200
LZ-4	do.		Zepplin Co.	15,000
LZ-5	do.	Z II	Military board	15,000
LZ-6	Friedrichshafen		Zepplin Co.	15,000
			Delag [1]	16,000
LZ-7	do.	Deutschland-Ersatz	do.	19,300
LZ-8	do.	Deutschland	do.	19,300
LZ-9	do.	Z II	Military board	16,800
		do. [1]	do.	17,800
LZ-10	do.	Schwaben	Delag	17,800
LZ-11	do.	Victoria Louise	do.	18,700
LZ-12	do.	Z III	Military board	17,800
LZ-13	do.	Hansa	Delag	18,700
LZ-14	do.	L I	Naval board	22,465

[1] After reconstruction. [2] After reconstruction of steering gear

Construction No.	Where built.	Name or mark.	Property of—	Capacity in cubic meters.
LZ-15	Friedrickshafen	Ersatz Z I	Military board	19,500
LZ-16	do	Z IV	do	19,500
LZ-17	do	Sachsen	Delag	19,500
		Sachsen [3]	do	20,870
LZ-18	do	L 2	Naval board	27,000
LZ-19	do	Desatz Z I	Military board	19,500
LZ-20	do	Z V	do	19,500
	do	Z V	do	20,870
LZ-21	do	Z VI	do	20,870
LZ-22	do	Z VII	do	22,140
LZ-23	do	Z VIII	do	22,140
LZ-24	do	L 3	Naval board	22,500
LZ-25	do	X IX	Military board	22,500
LZ-26	Frankfort on the Main	Z XII	do	25,000
LZ-27	Friedrichshafen	L 4	Naval board	22,500
LZ-28	do	L 5	do	22,500
LZ-29	do	Z X	Military board	22,500
LZ-30	Potsdam	Z XI	do	22,500
LZ-31	Friedrichshafen	L 6	Naval board	22,500
LZ-32	do	L 7	do	22,500
LZ-33	do	L 8	do	22,500
LZ-34	Potsdam	LZ 34	Military board	22,500
LZ-35	Friedrichshafen	LZ 35	do	22,500
LZ-36	do	L 9	Naval board	25,000
LZ-37	Potsdam	LZ 37	Military board	22,500
LZ-38	Friedrichshafen	LZ 38	do	32,000
LZ-39	do	LZ 39	do	25,000
LZ-40	do	L 10	Naval board	32,000
LZ-41	Loewenthal	L 11	do	32,000
LZ-42	Potsdam	LZ 72	Military board	32,000
LZ-43	Friedrichshafen	L 12	Naval board	32,000
LZ-44	Loewenthal	LZ 74	Military board	32,000
LZ-45	Friedrichshafen	L 13	Naval board	32,000
LZ-46	Loewenthal	L 14	do	32,000
LZ-47	Friedrichshafen	LZ 77	Military board	32,000
LZ-48	Loewenthal	L 15	Naval board	32,000
LZ-49	Potsdam	LZ 79	Military board	32,000
LZ-50	Friedrichshafen	L 16	Naval board	32,000
LZ-51	Loewenthal	LZ 81	Military board	32,000
		LZ 81 [3]	do	35,800
LZ-52	do	LZ 18	Naval board	32,000
LZ-53	Friedrichshafen	L 17	do	32,000
LZ-54	do	L 19	do	32,000
LZ-55	Potsdam	LZ 85	Military board	32,000
LZ-56	do	LZ 86	do	32,000
			do [3]	35,800
LZ-57	Loewenthal	LZ 87	do	32,000
		LZ 87 [3]	do	35,800
LZ-58	Potsdam	LZ 88	do	32,000
		LZ 88 [3]	do	35,800
LZ-59	Friedrichshafen	L 20	Naval board	35,800
LZ-60	Potsdam	LZ 90	Military board	32,000
		LZ 90 [3]	do	35,800
LZ-61	Loewenthal	L 21	Naval board	35,800
LZ-62	Friedrichshafen	L 30	do	55,000
LZ-63	Potsdam	LZ 93	Military board	32,000
		LZ 93	do	35,800
LZ-64	Loewenthal	L 22	Naval board	35,800
LZ-65	Friedrichshafen	LZ 95	Military board	35,800
LZ-66	Potsdam	L 23	Naval board	35,800
LZ-67	Loewenthal	LZ 97	Military board	35,800
LZ-68	do	LZ 98	do	35,800
LZ-69	Potsdam	L 24	Naval board	35,800
LZ-70	Loewenthal	L 26	do	
LZ-71	Potsdam	LZ 101	Military board	35,800
LZ-72	Loewenthal	L 31	Naval board	55,000
LZ-73	Potsdam	LZ 103	Military board	35,800
LZ-74	Friedrichshafen	L 32	Naval board	55,000
LZ-75	Staaken	L 37	do	55,000
LZ-76	Friedrichshafen	L 33	do	55,000
LZ-77	Potsdam	LZ 107	Military board	35,800
LZ-78	Loewenthal	L 34	Naval board	55,000
LZ-79	Staaken	L 41	do	55,000
LZ-80	Friedrichshafen	L 35	do	55,000
LZ-81	Potsdam	LZ 111	Military board	35,800
LZ-82	Friedrichshafen	L 36	Naval board	55,000
LZ-83	Staaken	LZ 113	Military board	55,000
LZ-84	Loewenthal	L 38	Naval board	55,000
LZ-85	Staaken	L 45	do	55,000
LZ-86	Friedrichshafen	L 39	do	55,000
LZ-87	Staaken	L 47	do	55,000
LZ-88	Friedrichshafen	L 40	do	55,000
LZ-89	Staaken	L 50	do	55,000
LZ-90	Loewenthal	LZ 120	Military board	55,000
LZ-91	Friedrichshafen	L 42	Naval board	55,500
LZ-92	do	L 43	do	55,500
LZ-93	Loewenthal	L 44	do	55,800
LZ-94	Friedrichshafen	L 46	do	55,800
LZ-95	do	L 48	do	55,800
LZ-96	Loewenthal	L 49	do	55,800
LZ-97	Friedrichshafen	L 51	do	55,800
LZ-98	Staaken	L 52	do	55,800
LZ-99	do	L 54	do	55,800
LZ-100	Friedrichshafen	L 53	do	56,000
LZ-101	Loewenthal	L 55	do	56,000
LZ-102	Friedrichshafen	L 57	do	68,500
LZ-103	Staaken	L 56	do	56,000

[3] After elongation.

Construction No.	Where built.	Name or mark.	Property of—	Capacity in cubic meters.
LZ-104	Staaken	L 59	Naval board	68,500
LZ-105	Friedrichshafen	L 58	do	56,000
LZ-106	do	L 61	do	56,000
LZ-107	Loewenthal	L 62	do	56,000
LZ-108	Staaken	L 60	do	56,000
LZ-109	do	L 64	do	56,000
LZ-110	Friedrichshafen	L 63	do	56,000
LZ-111	Loewenthal	L 65	do	56,000
LZ-112	Friedrichshafen	L 70	do	68,150
LZ-113	do	L 71	do	62,200
LZ-114	Loewenthal	L 72	do	68,150
LZ-115 [4]				
LZ-116 [4]				
LZ-117 [4]				
LZ-118 [4]				
LZ-119 [4]				
LZ-120	Friedrichshafen	Bodensee Bodensee [3]	Delag do	22,560
LZ-121		Nordstern	do	22,560

[3] After elongation.

[4] Not built.

Construction No.	Velocity (meters per second).	First trip.	Put out of commission.	Remarks.
LZ-1	8	July 2, 1900	Spring, 1901	Dismantled at the factory.
LZ-2	11	Nov. 30, 1905	Jan. 17, 1906	Destroyed by storm after a forced landing at Kiessling, Allaueg.
LZ-3	11 12.2 15	Oct. 9, 1906		Antiquated; dismantled at the Metz shed.
LZ-4	12.5	June 20, 1908	Aug. 5, 1908	Forced landing at Echterdingen; destroyed by fire later.
LZ-5	12.5	May 26, 1909	Apr. 25, 1910	Forced landing at Weilburg; torn loose by storm and wrecked.
LZ-6	13 15.5	Aug. 25, 1909	Sept. 14, 1910 do	Destroyed by fire at shed at Baden-Oos.
LZ-7	16	June 19, 1910	June 28, 1910	Wrecked at Wallendorf (Teuburg Forest).
LZ-8	16	Mar. 30, 1911	May 16, 1911	Destroyed on starting from shed at Dusseldorf.
LZ-9	21.7 21	Oct. 2, 1911	Aug. 1, 1914	Antiquated; dismantled in the shed at Gotha.
LZ-10	21	June 26, 1911	June 28, 1912	Destroyed by fire at Dusseldorf.
LZ-11	[1] 21	Feb. 14, 1912	Autumn, 1915	Destroyed when entering the shed at Liegnitz.
LZ-12	[1] 21	Apr. 25, 1912	Summer, 1914	Antiquated; dismantled in shed at Metz.
LZ-13	[1] 21	July 30, 1912	Summer, 1916	Antiquated; dismantled at shed in Johannisthal.
LZ-14	21.2	Oct. 7, 1912	Sept. 9, 1913	Wrecked at Helgoland.
LZ-15	20.5	Jan. 16, 1913	Mar. 19, 1913	Forced landing at Karlsruhe and destroyed by storm.
LZ-16	20.9	Mar. 14, 1913	Autumn, 1916	Antiquated; dismantled in shed at Hutembog.
LZ-17	[1] 21 20	May 3, 1913	Autumn, 1916	Antiquated; dismantled in shed at Duren.
LZ-18	21	Sept. 9, 1913	Oct. 17, 1913	Descended in a burning state at Johannisthal.
LZ-19	20.4	June 6, 1913	June 13, 1914	Forced landing at Dedenhofen and wrecked.
LZ-20	20.5	July 8, 1913	Aug. 27, 1914	Shot down at Kipoviec (Mlawa) and wrecked.
LZ-21	20.3	Nov. 10, 1913	Aug. 6, 1914	Shot down at Luttich and wrecked at Cologne.
LZ-22	20.5	Jan. 8, 1914	Aug. 23, 1914	Shot down while reconnoitering and wrecked at St. Quirin.
LZ-23	20.2	Feb. 21, 1914	do	Hit by shell while reconnoitering and wrecked at Badenvillers.
LZ-24	21.5	May 11, 1914	Feb. 17, 1915	Wrecked by storm on the shore of Tano in consequence of the breakdown of all motors.
LZ-25	21.4	July 29, 1914	Oct. 8, 1914	Destroyed by English aviators in the shed at Dusseldorf.
LZ-26	21.4	do	do	Dismantled in the Juterbog shed on cessation of military airship aviation.
LZ-27	[1] 21.5	Aug. 28, 1913	Feb. 17, 1915	Driven by storm to Denmark and wrecked at Borsmose.
LZ-28	[1] 21.5	Sept. 22, 1913	Aug. 6, 1915	Shot down and wrecked at Mitau.
LZ-29	[1] 22	Oct. 13, 1914	Mar. 21, 1915	Hit by shell during an attack on Paris and wrecked at St. Quentin.
LZ-30	22	Nov. 11, 1914	May 20, 1915	Cast adrift by storm when leaving the shed at Posen; wrecked and destroyed by fire.
LZ-31	22	Nov. 3, 1914	Sept. 19, 1916	Destroyed by fire in the shed at Fuhlsbuttel.
LZ-32	22	Nov. 20, 1914	May 5, 1916	Brought down by shell while reconnoitering at Horns Riff.
LZ-33	22	Dec. 17, 1914	Mar. 5, 1915	Shot down and wrecked at Tirlemont.
LZ-34	22	Jan. 6, 1915	May 21, 1915	Shot down during an attack on Kowno, forced landing in East Prussia, cast adrift and destroyed by fire.
LZ-35	22	Jan. 11, 1915	May 13, 1915	Shot down during an attack on Poperinghe and wrecked at Thielt.
LZ-36	22	Mar. 8, 1915	Sept. 16, 1916	Destroyed by fire in the shed at Fuhlsbuttel.
LZ-37	22	Feb. 28, 1915	June 7, 1915	Hit by aviators at Ghent after an attack on Calais.

[1] About.

Construction No.	Velocity (meters per second).	First trip.	Put out of commission.	Remarks.
LZ-38	23	May 3, 1915	June 7, 1915	Destroyed in the shed at Brussels by English aviators.
LZ-39	21.5	Apr. 24, 1915	Oct. 18, 1915	Shot down during an attack on Rowno and wrecked at Luck.
LZ-40	[1] 25	May 13, 1915	Sept. 3. 1915	Struck by lightning, at Cuxhaven and descended in a burning state.
LZ-41	[1] 25	June 7, 1915	Apr.—, 1917	Antiquated; dismantled in the shed at Hage.
LZ-42	[1] 25	June 15, 1915	Feb. 16, 1917	Dismantled in the shed at Juterbog in consequence of the cessation of military aviation.
LZ-43	[1] 25	June 21, 1915	Aug. 10, 1915	Shot down during an attack on England, dragged into the port of Ostend and there burned.
LZ-44	[1] 25	July 8, 1915	Oct. 8, 1915	Collision at Berg in Belgium and wrecked.
LZ-45	[1] 25	July 23, 1915	Apr.—, 1917	Antiquated; dismantled in shed at Hage.
LZ-46	[1] 25	Aug. 9, 1915	July—, 1919	Destroyed in shed at Nordholz.
LZ-47	[1] 25	Aug. 24, 1915	Feb. 21, 1916	Shot down at Revigny.
LZ-48	[1] 25	Sept. 9, 1915	Apr. 1, 1916	Forced landing at the mouth of the Thames after an attack on England and sunk.
LZ-49	[1] 25	Aug. 2, 1915	Jan. 20, 1916	Shot down during an attack on Paris, forced landing at Ath and wrecked.
LZ-50	[1] 25	Sept. 23, 1915	Oct. 19, 1917	Destroyed in consequence of difficult landing at Nordholz.
LZ-51	[1] 25	Oct. 7, 1915	Sept. 27, 1916	Shot down during attack on Bucarest, forced landing at Trnovo and wrecked.
LZ-52	[1] 25	Nov. 3, 1915	Nov. 17, 1915	Destroyed by fire in shed at Tondern.
LZ-53	[1] 25	Oct. 20, 1915	Dec. 28, 1916	Do.
LZ-54	[1] 25	Nov. 27, 1915	Feb. 2, 1916	Sunk in the North Sea.
LZ-55	[1] 25	Sept. 12, 1915	May 5, 1916	Shot down during attack on Saloniki, forced landing at the Wardar and wrecked.
LZ-56	[1] 25	Oct. 10, 1915	Sept. 4, 1916	Destroyed in consequence of difficult landing at Temesvar.
LZ-57	[1] 25	Dec. 6, 1915	July 28, 1917	Dismantled in the shed at Juterbog in consequence of cessation of military airship aviation.
LZ-58	[1] 25	Nov. 15, 1915	Sept. 15, 1917	Taken over by the naval board as trial ship L-25, antiquated and dismantled in shed at Potsdam.
LZ-59	[1] 25	Dec. 21, 1915	May 3, 1916	Driven to Stavanger in consequence of defective motors after an attack on England and wrecked.
LZ-60	[1] 25	Jan. 1, 1916	Nov. 7, 1916	Torn loose without a crew by storm at Wittmund and lost at sea.
LZ-61	25	Jan. 10, 1916	Nov. 28, 1916	Brought down on the English coast at Lowestoft.
LZ-62	27.8	May 28, 1916	Summer, 1920	Dismantled in shed at Seerappen.
LZ-63	25	Feb. 23, 1916	Summer, 1917	Dismantled in the shed at Trier in consequence of cessation of militare airship aviation.
LZ-64	25	Mar. 3, 1916	May 14, 1917	Brought down by torpedo boats at Terschelling.
LZ-65	[2] 25	Jan. 31, 1916	Feb. 22, 1916	Hit by shell while crossing the front in the Champagne and wrecked at Namur.
LZ-66	([2])	Apr. 8, 1916	Aug. 22, 1917	Brought down by torpedo boats at Horns Riff.
LZ-67	([2])	Apr. 4, 1916	July 5, 1917	Dismantled in the shed at Juterbog in consequence of cessation of military airship aviation.
LZ-68	([2])	Apr. 28, 1916	Aug.—, 1917	Dismantled for same reason at shed at Schneidemuehl.
LZ-69	([2])	May 20, 1916	Dec. 28, 1916	Destroyed by fire in the shed at Tondern.
LZ-70 [3]				
LZ-71	25	June 29, 1916	Sept.—, 1917	Dismantled in consequence of cessation of military airship aviation in shed at Juterbog.
LZ-72	27	July 12, 1916	Oct. 2, 1916	Brought down by shell during an attack on London.
LZ-73	25	Aug. 8, 1918	Aug.—, 1917	Dismantled in the shed of Konigsberg in consequence of cessation of military airship aviation.
LZ-74	[1] 27	Aug. 4, 1916	Sept. 24, 1916	Brought down by shell during an attack on London.
LZ-75	[1] 27	Nov. 9, 1916	Summer, 1920	Taken apart in the shed of Seddin, to be reconstructed in Japan.
LZ-76	[1] 27	Aug. 30, 1916	Sept. 24, 1916	Hit by shell, forced landing at Brentwood (Engand) and dismantled there.
LZ-77	25	Oct. 16, 1916	July—, 1917	Dismantled at shed at Darstadt in consequence of cessation of military airship aviation.
LZ-78	[1] 27	Sept. 22, 1916	Nov. 28, 1916	Brought down by English aviators at Scarborough (English coast).
LZ-79	[1] 27	Jan. 15, 1917	July —, 1917	Destroyed in the shed at Nordholz.
LZ-80	[1] 27	Oct. 12, 1916	Summer, 1918	Antiquated; dismantled in the shed at Juterbog.
LZ-81	25	Dec. 20, 1916	Aug. 10, 1917	Dismantled in the shed at Dresden in consequence of cessation of military airship aviation.
LZ-82	27	Nov. 1, 1916	Feb. 7, 1917	Wrecked in the fog at Rethem (Aller).
LZ-83	[1] 28	Feb. 22, 1917	Oct. 8, 1920	Transported from Seddin to Maubeuge and delivered to the French.
LZ-84	[1] 28	Nov. 22, 1916	Dec. 29, 1916	Wrecked at Seemuppen, (Russia).
LZ-85	[1] 28	May 2, 1917	Oct. 20, 1917	Wrecked in the Valley of the Saone after an attack on England.
LZ-86	[1] 28	Dec. 11, 1916	Mar. 17, 1917	Brought down by shell at Compiegne.
LZ-87	[1] 28	May 1, 1917	Jan. 5, 1918	Destroyed by fire in consequence of an explosion in the shed at Ahlhorn.

[1] About. [2] Recorded. [3] Discontinued. Construction of airships of 55,000 m^3 commenced.

Construction No.	Velocity (meters per second).	First trip.	Put out of commission.	Remarks.
LZ-88...	[1]28	Jan. 3, 1917	June 17, 1917...	Wrecked at Neuenwalde (Geestemunde).
LZ-89...	[1]28	June 9, 1917	Oct. 20, 1917...	Incidental landing at Montigny le Roi (France) after an attack on England and wrecked in Switzerland.
LZ-90...	[1]28	Jan. 31, 1917	....	Shortly to be transported from Seerappen near Konigsberg to Rome and delivered to Italy.
LZ-91...	[1]27	Feb. 21, 1917	July—, 1919..	Destroyed in the shed at Nordholz.
LZ-92...	[1]27	Mar. 6, 1917	June 14, 1917..	Brought down by English military forces over the North Sea.
LZ-93...	[1]27	Apr. 1, 1917	Oct. 20, 1917...	Driven by storm after an attack on England and brought down by shells in France.
LZ-94...	[1]27	Apr. 24, 1917	Jan. 5, 1918....	Destroyed by explosion in the shed at Ahlhorn.
LZ-95...	[1]29.5	May 22, 1917	June 17, 1917...	Brought down by shell at Ipswich.
LZ-96...	[1]29.5	June 13, 1917	Oct. 20, 1917....	Driven by storm after an attack on England at Bouchen les Bains and wrecked in France.
LZ-97...	[1]29.5	July 6, 1917	Jan. 5, 1918....	Destroyed by fire in the shed at Ahlhorn.
LZ-98...	[1]29.5	July 4, 1917	Aug. —, 1919..	Destroyed in the shed at Wittmund.
LZ-99...	[1]29.5	Aug. 13, 1917	July 19, 1918..	Destroyed by English aviators in the shed at Tondern.
LX-100.	30	Aug. 18, 1917	Aug. 11, 1918...	Shelled at Terschelling.
LZ-101..	30	Sept. 1, 1917	Oct. 20, 1917...	Hit by shell during an attack on England and wrecked at Tiefenort (Werra).
LZ-102..	28	Sept. 26, 1917	Oct. 7, 1917....	Destroyed by fire in front of the shed at Juterbog.
LZ-103..	30	Sept. 24, 1917	Aug. —, 1919...	Destroyed in the shed at Wittmund.
LZ-104..	28	Oct. 10, 1917	Apr. 7, 1918....	Descended in a burning state in the streets of Otranto (cause unknown).
LZ-105..	[1]32	Oct. 29, 1917	Jan. 5, 1918....	Destroyed by explosion in shed at Ahlhorn.
LZ-106..	[1]32	Dec. 12, 1917	Aug. 29, 1918...	Transported from Wittmund to Rome and delivered to Italy.
LZ-107..	[1]32	Jan. 19, 1918	May 10, 1918...	Descended in Helgoland.
LZ-108..	[1]32	Dec. 18, 1917	July 19, 1918...	Destroyed by English aviators in the shed at Tondern.
LZ-109..	[1]32	Mar. 11, 1918	July 22, 1920...	Transported from Ahlhorn to Pulham and delivered to England.
LZ-110..	[1]32	Mar. 4, 1918	July —, 1919...	Destroyed in the shed at Nordholz.
LZ-111..	[1]32	Apr. 17, 1918	.....do........	Do.
LZ-112..	[1]36	July 1, 1918	Aug. 5, 1918....	Brought down by shell at Boston.
LZ-113..	[1]36	July 29, 1918	July 1, 1920....	Transported from Ahlhorn to Pulham and delivered to England.
LZ-114..	[1]36	July 9, 1920	....	Transported from Loewenthal to Maubeuge and delivered to France.
LZ-115[4]	....	....	....	
LZ-116[4]	....	....	....	
LZ-117[4]	....	....	....	
LZ-118[4]	....	....	....	
LZ-119[4]	....	....	....	
LZ-120..	[1]37	Aug. 20, 1919	....	After elongation not commissioned, owing to prohibition by Entente.
LZ-121..	....	....	....	Not commissioned, owing to prohibition by Entente.

[1] About

[4] Not built.

ACCIDENTS TO ZEPPELINS.

1. *Airship No. II* (no designation). Was forced down by a storm at Kiessling; ship could not be controlled, due to heavy wind. Made forced landing. Blown against trees (or buildings); frame broke, could not be repaired. Cause: Lack of power to make headway against storm. January 17, 1906.

2. *Airship No. IV* (no designation). Was compelled to land, due to lack of buoyancy, at Echterdingen. In attempting to make repairs one of the gas cells caught fire and the ship was burned. Cause: Lack of proper precautions in deflating. August, 1908.

3. *Z-II.* Was compelled to land, on account of motor trouble, at Woilking. Not sufficiently held down; while awaiting minor repairs a storm broke, tore airship from moorings, and carried it off; destroyed when crashed into the ground. April, 1910.

4. *Airship No. 6* (no designation). Burned up when a fire broke out in the hangar at Badenoos. September 14, 1910.

5. *Deutschland* (*I*). Was compelled to land on account of lack of lift (leaky gas bags) on the trees, in Teutoberger Forest. Airship could not be salvaged and it became necessary to break it up June 28, 1910.

6. *Deutschland* (*II*). Was caught in a wind gust on emerging from hangar (due to presence of windbreaks). Airship was thrown against side of hangar door and broken. Could not be repaired. May 16, 1911.

7. *Schwaben.* Was burned up at Dusseldorf, due to fire in hangar, June 28, 1912. (No details are now available.)

8. *Victoria Louise.* Was broken on entering hangar at Leegnitz, due to very strong wind, insufficient hangar space, and untrained handling detachment. Airship was carried against side of hangar, caught in framework of latter, and the frame of the airship was broken. Autumn, 1915.

9. *L-I.* Was carried out to sea by strong wind, due to lack of buoyancy, and stranded at Helgoland, September, 1913. (No further details now available.)

10. *Z-I* (substitute). Was compelled to make an emergency landing on account of a severe storm. Could not be properly moored down. The force of the storm drove the airship against the ground on its moorings and broke the frame. March 19, 1913.

11. *L-II.* Caught fire in the air, due to spark from the motor exhaust (due to motor being too close to envelope). Burned up. Johannisthal, October 17, 1913.

12. *Z-I* (second substitute). Emergency landing due to lack of gas (bad piloting and leaky gas cells). Could

not be moored down, account local conditions (no means of attachment). Ship broken on landing and later severely damaged by force of wind while on ground. June 13, 1914.

13. *Z–V.* No report.

14. *Z–VI.* No report.

15. *Z–VII.* No report.

16. *Z–VIII.* No report.

17. *L–III.* All three motors stopped, and to prevent being carried out to sea was landed on a small island in Baltic. Severe storm at the time severely damaged airship on landing, and it was later more damaged, so that it could not be repaired. February 17, 1915.

18. *Z–IX.* Destroyed in hangar by British aviators. Bombed hangar, and set fire to airship. Dusseldorf, October 8, 1914.

19. *L–IV.* Was driven to Denmark by severe storm (due to lack of dirigibility), landed, and destroyed. February 17, 1915.

20. *L–V.* Struck by hostile projectiles and fell (no information available). March 21, 1915.

21. *Z–X.* No report.

22. *Z–XI.* Was carried off on taking out of hangar (due to wind, lack of sufficient handling crew, and local conditions); landed in enemy territory and burned up by crew. May 20, 1915.

23. *L–VI.* Burned up as a result of fire in the hangar at Fruhlsbuttel. (No details available.) September, 1916.

24. *L–VIII.* Struck by enemy projectiles, forced to land on account of loss of gas and damaged controls. Could not be repaired. Tirlemenet, March 5, 1915.

25. *L–VII.* Was struck and severely damaged by hostile artillery fire; compelled to land in water and sunk. May 4, 1915.

26. *LZ–34.* Was damaged in bombing Kovno; lost gas and was compelled to make forced landing in East Prussia. Ship was blown against a building and fire from signal rockets ignited gas. May 21, 1915.

27. *LZ–35.* Was struck on making bombing attack on Poperinghe; lost gas and was landed at Thielt. Struck with great force, breaking frame, and could not be repaired. April 13, 1915.

28. *L–IX.* Burned in hangar at Fuhlsbuttel at same time as *L–6*.

29. *LZ–37.* Was attacked by airplanes and, due to loss of gas, fell near Ghent. Destroyed on landing. June 7, 1915.

30. *LZ–38.* Destroyed when hangar at Brussels was bombed. June, 1915.

31. *LZ–39.* Was struck in bombing Rovno and forced to land. Burned by crew to avoid capture. December 18, 1915.

32. *L–10.* Was struck by lightning and immediately caught fire over Cuxhaven. Burned up in the air. September 3, 1915.

33. *L–12.* Was struck by hostile artillery in bombing England. Landed on Belgian coast and carried overland to Ostend; damaged in last operation too severely to be repaired, and therefore burned. August 10, 1915.

34. *LZ–77.* Shot down at Revigny and burned by crew to avoid capture. February 21, 1916.

35. *L–15.* Was so severely damaged in bombing attack on England (due to planes and antiaircraft fire) that it was compelled to land at mouth of Thames. Sunk by crew to avoid capture. April 1, 1916.

36. *LZ–79.* Was damaged by antiaircraft and airplane fire on bombing Paris. Loss of gas compelled landing at Ath. No facilities for repairs, and ship was destroyed to avoid possibility of later capture by French. January 30, 1916.

37. *L–16.* Was damaged on entering Nordholz hangar, due to sudden wind gust driving it against the framework of latter. Was not deemed advisable to make repairs on account of it being an older type, and it was therefore destroyed. Cause of damage principally attributed to strong wind gust and presence of other airships in hangar. October 19, 1917.

38. *LZ–81.* Was struck several times by large-caliber projectiles over Bucharest; forced, account of loss of gas, to make an emergency landing and abandoned as being beyond repair, due to both causes. September 27, 1916.

39. *L–17* and *L–18.* Burned up when a fire broke out in the hangar at Tondern. There were two separate fires (November 17, 1915, and December 28, 1915), due to same cause (ignition of inflammable material).

40. *L–19.* Sunk in the North Sea. Cause not definitely known, probably as a result of hostile aircraft or gun fire. November 27, 1915.

41. *LZ–85.* Struck numerous times by hostile fire at Saloniki, lost gas and forced to land. Unable to be repaired and therefore broken up. May 5, 1916.

42. *LZ–86.* Attempted to land in a high wind and with a new crew. Crashed into a tree (or trees), broke nose and cars. Was too severely damaged to be repaired. September 4, 1916.

43. *L–20.* On a bombing raid over England, was driven off by British airplanes. On return trip developed serious motor trouble and was no longer dirigible. Made a forced landing at Stavenger. Could not be repaired. May 3, 1916.

44. *LZ–90.* Was torn from its moorings at Wittmund in a sudden storm before it could be housed. Was carried away to sea and disappeared with no personnel aboard. November 7, 1916.

45. *L–21.* Was shot down, probably by British aircraft, near the English coast. No details known. November 28, 1916.

46. *L–22.* Attempted to bomb a British submarine near Terschilling. Was caught by British torpedo boats and shot down by gunfire from the latter. May 14, 1917.

47. *LZ–95.* Was struck by hostile gunfire on crossing over the lines in Champagne. Turned and made a forced landing at Namur, but was too badly damaged to be repaired. February 26, 1916.

48. *L–23.* An accident similar in every respect to that of *L–22*.

49. *LZ–98.* Burned up with *L–17* in the hangar at Tondern.

50. *LZ–101.* Shot down in a bombing raid over London; no details known. October 2, 1916.

51. *L–32.* Shot down in an attack on London. Struck by antiaircraft fire and compelled to descend to a lower level where it was attacked by planes and finally compelled

to land in the North Sea. Was sunk. September 24, 1916.

52. *L–33*. Shot down by British airplanes at Brentwood England. Lost gas; made a forced landing and was broken up by crew to avoid capture. September 24, 1916.

53. *L–34*. Shot down by British aviators over Scarborough, England. Compelled to land, account of loss of gas, and sunk in North Sea. November 28, 1916.

54. *L–36*. Lost its way in a fog and made a forced landing at Rethem. Severely damaged on landing and was broken up. February 7, 1917.

55. *L–38*. Compelled to land in Russia and was either broken up by crew or captured (details unknown). December 29, 1916.

56. *L–45*. After an attack in England, lost its bearings and flew over France. Fog prevented orientation and finally was compelled to land, account of no fuel and lack of gas. Captured by French, October 20, 1917.

57. *L–39*. Shot down in attempting to cross lines near Compiegne. Ship was compelled to land almost immediately and was captured. March 17, 1917.

58. *L–47*. Destroyed in Ahlhorn when fire broke out and gas bags were ignited. Ship exploded when it caught fire. January 5, 1918.

59. *L–40*. Compelled to land near Neuenwalde, and broken up (no details known). June, 1917.

60. *L–50*. Followed *L–45* over France. Made a forced landing at Montigny, discovered its location and then flew to Switzerland. Broken up there and crew interned. October 20, 1917.

61. *L–43*. Shot down and destroyed by British planes in North Sea. (No details known.) June, 1917.

62. *L–44*. Followed *L–45* over France, and was forced to land in France on account of lack of gas and motor trouble. Badly damaged by gunfire from French antiaircraft cannon.

63. *L–46*. Destroyed with *L–47* at Ahlhorn hangar.

64. *L–48*. Compelled to land at Ipswich, England, on account of loss of gas and motor trouble, due to British antiaircraft. June 17, 1917.

65. *L–49*. Followed *L–45* over France, ran out of fuel and was leaking gas badly. Forced to land at Bouchon les Bains and captured before it could be broken up or destroyed.

66. *L–51*. Destroyed in Ahlhorn hangar with *L–46* and *L–47*.

67. *L–54*. Was destroyed in hangar at Tondern when the hangar was bombed by British planes. Bomb struck the airship and it exploded. July 19, 1918.

68. *L–53*. Was compelled to land at Terschelling on account of lack of gas, due to shot holes in bags. Broken up and destroyed. August 11, 1918.

69. *L–55*. Was severely damaged by antiaircraft gunfire when attacking England with *L–44*, *L–45*, *L–49*, and *L–50*. Attempted to regain its hangar at Ahlhorn but was forced to land at Tienfenert, and broken up.

70. *L–57*. Was designed to take the trip to German East Africa, but on coming back from a flight, was burned up on catching fire when about to be taken into the hangar. Fire due to burning gasoline from the motor. October 7, 1917.

71. *L–59*. No details of this accident are known, except that the airship was observed crossing the Straits of Otranto, and suddenly caught fire. It dropped into the water burning, and there were no survivors. April 7, 1918.

72. *L–58*. Was destroyed in the hangar at Ahlhorn with *L–46*, *L–47*, and *L–51*.

NOTE.—The explosion in one of the Ahlhorn hangars caused a general outbreak of fire which spread to the adjoining hangars.

73. *L–62*. Was cruising in North Sea, and compelled to make forced landing on Helgoland. Driven violently against rocks by storm and broken to pieces. May 10, 1918.

74. *L–60*. Was destroyed in the hangar at Tondern by British planes, at the same time as *L–54*.

75. *L–70*. Was shot down by British planes and antiaircraft gunfire at Boston. Ship was destroyed to avoid capture. August 5, 1918.

NOTE.—The above represents the principal accidents to Zeppelins. There were, of course, several other accidents of a minor nature, but it was not possible to obtain the details.

The *Bodensee* is now in possession of the Italian Air Service and located at Cianino, the Italian lighter-than-air station located just outside of Rome. This machine is in full flight operation. The *Nordstorn* has been taken over by the French Air Service and is located just outside of Paris and is in flying condition. The *L–72* has also been taken over by the French Air Service and is located at Cuers. It was described under France.

THE COMPARISONS OF AIRSHIPS AND THE USE OF NONDIMENSIONAL CHARACTERISTICS.

When describing airships, their characteristics are usually expressed in terms of the ship's size and engine power as well as of lift and speed. These figures tell what performance each particular ship is able to give and what structural weight and power have been required in order to make this performance possible. In this case performance means the greatest absolute speed in a horizontal direction and the greatest useful load that the airship can carry.

Even with standard atmospheric conditions it is difficult to compare ships of different types or makes because the data is not referred to a common basis. To compare the standard type of data available will prove to be misleading in a great many cases, especially if use is made of them by some one not thoroughly acquainted with this highly specialized branch of engineering.

In order to make the above-named characteristics of use for comparative purposes, each absolute quantity must be related to some other known quantity of equal dimension in order that nondimensional values will be obtained. The conditions for the balance of forces on the mechanically propelled airship suggest themselves as a suitable form of relation.

As the propelling force is counterbalanced by the resistance of the hull and its accessories, the speed at which an ariship of given size can be driven by the horsepower installed depends on the efficiency of conversion of that power available at the crank shaft into useful thrust and on the quality of the airship with regard to drag. This quality is affected only by the external form of the ship

and may be conveniently expressed by the drag coefficient, which like the efficiency of conversion of power is non-dimensional. If put into mathematical form the forces acting on an airship in motion may be written as follows:

Air screw thrust in kilograms.

$$P-75E\times N/v$$

Resistance in kilograms.

$$W-D\text{-}c\times Y/g\times J2/3\times v2$$

where v is the velocity of the airship in meters per second.

N is the total horsepower available at the crank shaft.

E is the efficiency of the air screw and the transmission gear.

J is the volume of the airship in cubic meters.

D–c is the drag coefficient of the hull and accessories.

As the forces P and W must be in equilibrium, the above equation may be reduced to the following:

$$E/D\text{-}c-Y/g\times J2/3\times v3/75N$$

which represents the efficiency of propulsion. It shows the degree of perfection which the air screws and gears as well as the external form of the airship has attained and also therefore serves as a common measure from the aerodynamic point of view for all types and sizes of airships.

The disposable lift, that is the proportion of the total lift which is available for fuel and oil, ballast, stores, crew, passengers, mail, and freight, after allowing for all structural weights and machines, is determined by the magnitude of these dead weights and by the normal lifting power of the gas which gives the ship its buoyancy.

If "A" is the total lift of the ship for some specified atmospheric condition, and "G" the total dead weight, while "Q" is the useful load, then A minus G equals Q. The efficiency of structural design may be expressed as the ratio of disposable lift to dead weight:

$$y=Q/G=A/Q-1$$

which is called the *lifting efficiency*.

It can be used to illustrate the comparative degree of efficiency to which the structural design and the disposition of materials has been developed in different types and makes of airships of similar size and speed and of similar requirements. When comparing airships of different size and speed and equipped for different kinds of service, due consideration must be taken of the fact that in ships of similar design, structural dead weight is consuming smaller portions of the total lift as size increases and speed decreases, and that the weight allowed for accommodation of the paying load depends very much on the kind of load to be carried and in passenger ships on the margin of comfort to be provided.

By a somewhat arbitrary combination, namely, by forming the product of the values representing the efficiency of propulsion and the lifting efficiency, a third expression is obtained:

$$L=E/Dc\times t$$

This shows the qualities of an airship from both the aerodynamic and structural point of view.

This data was prepared by P. Jaray and furnished by Doctor Eckner of the Zeppelin Co.

Comparative chart of contents, velocity, and load of various representative Zeppelin airships.

Type.	Gas content (cubic meters).	Velocity.		Useful load.	Useful load.
		Meters per second.	Miles per hour.		
LZ-7	19,300	16.7	37.3	6.8	30.3
LZ-120	20,000	36.8	82	10.0	43.0
LZ-14	22,470	21.2	47.4	9.4	36.0
LZ-26	25,000	22.2	49.5	12.2	42.0
LZ-38	31,000	27	60.3	16.2	43.7
LZ-100	36,000	31.8	71	40.0	61.3
LZ-102	68,500	28.6	64	52.1	65.4
Design 301	[1] 70,000	35.5	79.3	42.0	[2] 51.7
Design 275	[1] 100,000	37.5	84	65.0	[2] 55.9
Design 296	[1] 135,000	33.3	74.5	90.4	[2] 57.6

[1] Estimated.
[2] These ships are passenger carriers with large cabins.

Design 301 is United States estimate; 296 is estimate for Spain, Argentine route.

COMPARISON OF DIRIGIBLES.

Figures 2 and 3 are two charts. Figure 2 shows the greater values of the Zeppelin when compared with the Schuttelanz *SL-22*, the English rigids *R-33*, *R-36*, and *R-80*, or the four nonrigids which are given in the bottom figure *B-NS*, *T-34*, *PL-27*, *T-2*. B is the United States blimp and PL, the Parceval. Figure 3 shows proposed and altered cabin for the United States ship (design 301), whose contents are to be about 70,000 cubic meters.

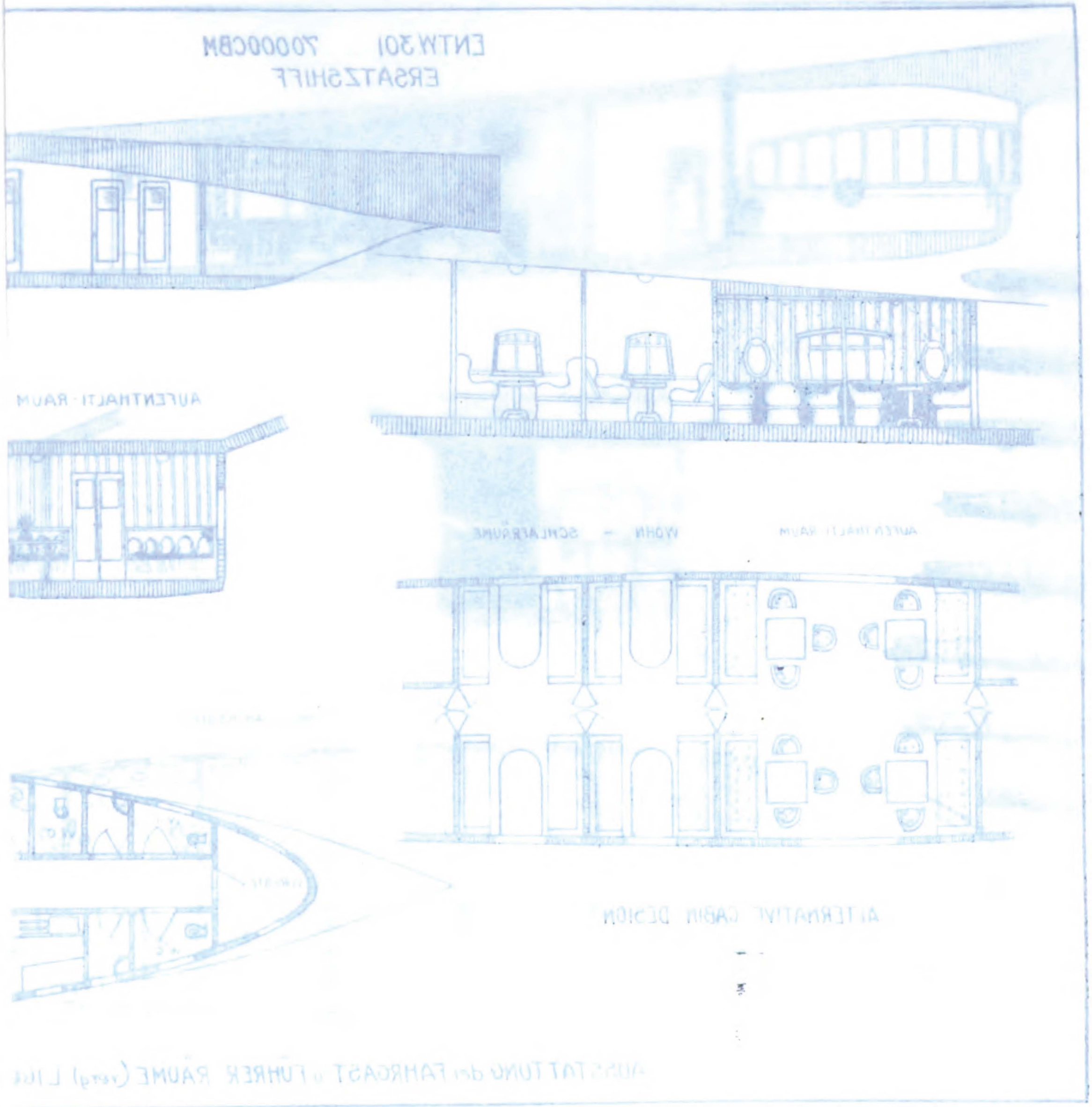
The charts are self-explanatory and show the latest German, Italian, British, French, and American rigid and nonrigid ships.

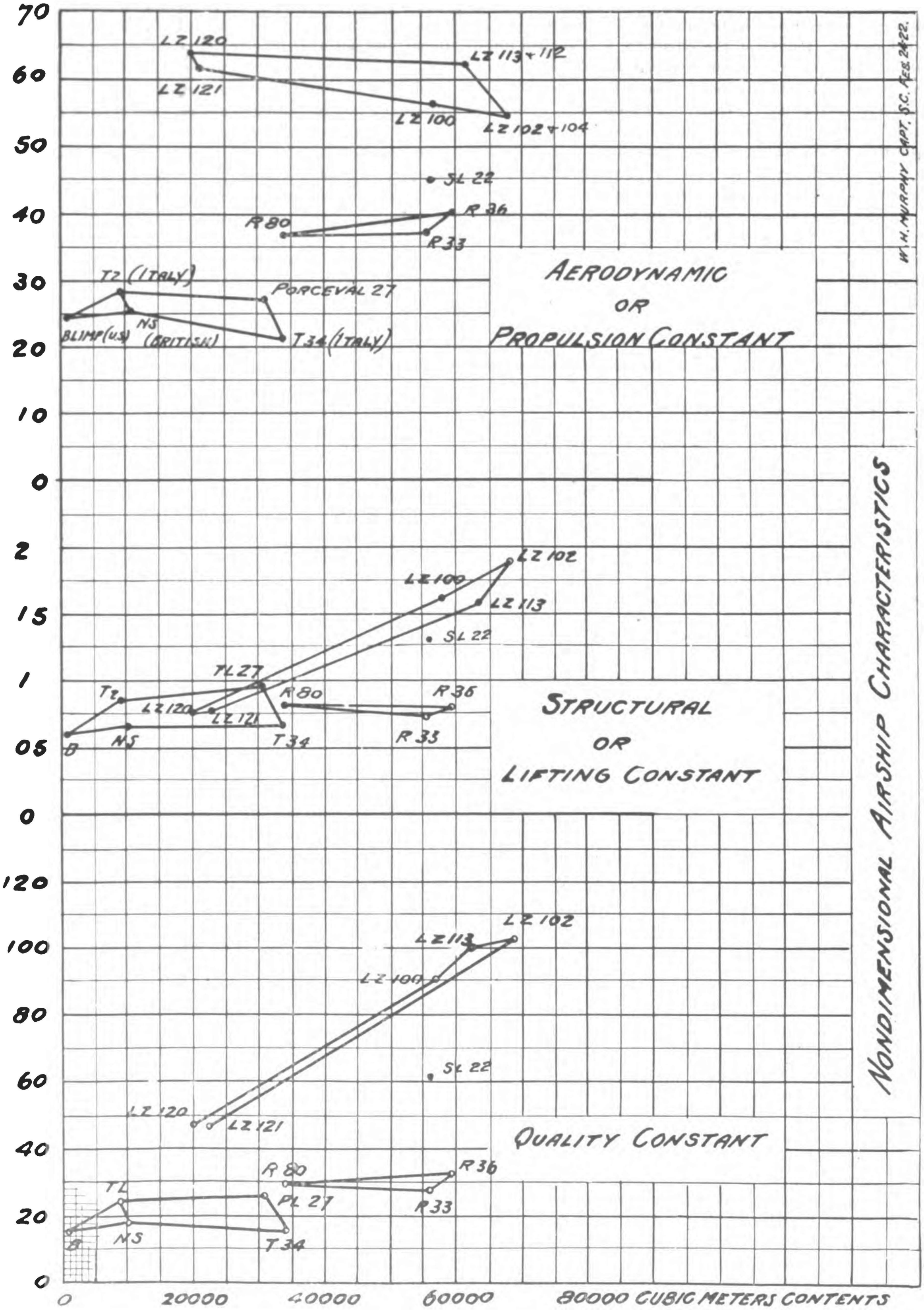
ZEPPELIN-DORNIER CO.

The Zeppelin-Dornier Co. is located at Friedrichshafen, and Mr. Dornier had been placed in absolute charge of designs and construction of all-metal heavier-than-air work for the Zeppelin Co. Doctor Rohrbach was formerly with the Zeppelin Co. and had charge of heavier-than-air all-metal design work at their Staaken plant outside of Berlin, but he has since severed connections to associate himself with Doctor Rumpler. There is no necessity for describing the older types of Dornier machines that were built prior to 1918. They were principally of the flying boat, monoplane type.

One of the later types developed in 1918, called the *D-1*, a single-seater pursuit, powered with a 180-B. M. W. engine and constructed of metal throughout, even to the covering of the wings, was a very interesting departure from all-metal airplane construction in Europe. This machine has a spread of 7.8 meters, length over all of 6.4 meters, area of 18.6 square meters, carries a live load of 180 kilograms, and weighs, empty, 690 kilograms.

The wing construction is characteristic of Dornier standard type. It has built-up steel wing spars of high tensile alloy shapes and is trellised in Warren truss fashion with alloy steel shapes. The spar channels are V shape and are joined on the free edges by a channel in common to both edges which is riveted. The webbing truss as heretofore referred to terminates in the spar channels with alloy


ENTW 301 70000CBM
ERSATZSHIFF
AUFENTHALTI-RAUM
WOHN - SCHLAFRÄUME
ALTERNATIVE CABIN DESIGN


70
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120
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60
40
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0
LZ 120
LZ 113 + 112
LZ 121
LZ 100
LZ 102 + 104
SL 22
R 80
R 36
R 33
T2 (ITALY)
PORCEVAL 27
BLIMP (US)
NS (BRITISH)
T 34 (ITALY)
AERODYNAMIC OR PROPULSION CONSTANT
LZ 102
LZ 100
LZ 113
SL 22
TL 27
T2
R 80
R 36
LZ 120
LZ 121
B
NS
T 34
R 33
STRUCTURAL OR LIFTING CONSTANT
LZ 102
LZ 113
LZ 100
SL 22
LZ 120
LZ 121
QUALITY CONSTANT
R 80
R 36
TL
PL 27
R 33
B
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0
20000
40000
60000
80000 CUBIC METERS CONTENTS
NONDIMENSIONAL AIRSHIP CHARACTERISTICS
W. H. MURPHY CAPT. S.C. FEB. 24 '22.

FIG. 2.

steel gusset plates. The whole wing is covered with duralumin sheets which are joined together in conventional steel roofing fashion at the edges by a U-shaped duralumin strip which overlaps the flat duralumin covered edges and is riveted thereto. The ailerons are attached to the top wing only. There is an absence of interplane struts, which to all appearances gives the machine a questionable appearance from a standpoint of structural resistance to deformation under the heavily stressed conditions of flight in nose dive or sharp maneuvering.

Landing gear struts are built up to duralumin streamline shapes which are bolted at the root to the fuselage shell proper. The main gasoline tank is suspended underneath the fuselage. The fuselage is built up of duralumin channel longerons and channel annular ribs with several longitudinal duralumin channel stringers which are all riveted to flat duralumin sheets which form the covering of the fuselage. It is analogous in principle to standard boat hull construction and seems a fair manufacturing proposition from all appearances. The fin is built integral with the fuselage.

The ribs of all the surfaces, including wings, movable surfaces, and fixed surfaces, are a flat duralumin sheet with circular lightening holes that are flanged at the edges to give them their proper degree of stiffness. This machine has a Junker type nose radiator. The machine is really a forerunner of the modern Dornier interpretation of all-metal construction which has been followed in practically all the later models. He has developed a different wing construction, however, and has used it in some models.

DO. G1, 1920—TWO-ENGINE DORNIER PASSENGER AIRPLANE.

Characteristics of this job are as follows:

- Length, over all: 12.20 meters.
- Span: 21 meters.
- Chord: 4 meters.
- Maximum height: 3.33 meters.
- Wing area: 80 square meters.
- Engines: 2 B. M. W., 185 horsepower, with tractor propellers.
- Fuel required, throttle wide open—
  - Gasoline: 60 gallons.
  - Oil: 4 gallons.
- Fuel required, at normal speed—
  - Gasoline: 60 gallons.
  - Oil: 4 gallons.
- Weight, empty: 23.50 kilograms.
- Weight, loaded, including cooling water and oil: 34.50 kilograms.
- Maximum speed: 180 kilometers per hour.
- Average traveling speed: 150 kilometers per hour.
- Maximum altitude, fully loaded: 6,000 meters.

This machine is a monoplane without flying wires, and like all the other Dornier machines is constructed of metal throughout. All vital parts are of high-grade steel, while the less important structural parts are of duralumin. The wings are covered with easily detachable sheets of duralumin. If desired, however, fabric may be used for the wing covering, in which case the carrying capacity of the machine is increased by 180 kilograms. The construction of the wings is somewhat different from the conventional Dornier type construction. The spars are of the regular high alloy steel construction, but the regular duralumin ribs have been dispensed with in favor of twin web duralumin box ribs situated about 75 per cent of the chord length apart and maintaining rigidity by stiffened duralumin wing covering through the use of duralumin channel stringers in a span sense. The covering is divided into sections between these box ribs and, of course, is fastened at these box rib sections in the usual Dornier way. It is understood that all these fastenings are external and in any case, if it is necessary, the covering can be very readily removed. The wing is absolutely devoid of internal bracing.

Special care has been taken, as is evidenced in the power plant installation, to secure accessibility to all the pipes and the ignition system. As the motors are situated one on either side of the main fuselage, the installation lends itself very well to accessibility. The engine beds extend from a small fuselage wing butt truss which terminates at the motor mounting extremity with landing gears underneath.

The pilot is located immediately ahead of the main wing in the nose of the fuselage and the passenger or bomb compartments are located immediately back of the pilot under the main wing. The propellers have been arranged well forward and are placed in a staggered position so in case of one propeller breaking no danger will occur either to the body, to the wings of the machine, or to the other propeller. The chassis of the machine is designed as a rigid frame. When landing, the impact of the machine is neutralized immediately. If, during emergency landing on rough ground, the machine should turn over on its nose, the passengers are safeguarded as much as possible from injury due to the fact that the motors would be first to hit the ground and thus absorb most of the shock of impact. The heaviest weights are neutralized before the tail of the machine could come in contact with the ground.

The passenger cabin is separated from the pilot cabin by the luggage room and is situated in the part of the machine which offers the best security. Considerable attention has been devoted to the design of gasoline and oil stores. In order to minimize the danger of fire, the gasoline is stored outside of the body of the machine so that the gases can not penetrate into the cabin, and gasoline from leaky tanks can not run over the engines in case of bad landings.

There are no flying wires or braces and apparently the strength and rigidity of the whole job could be assumed as being quite safe. The propeller tip circles come close to one another, due to the fact that the fuselage has been cut off short. This allows the motors to be brought in closer together, and the extent of the dangerous thrust couple that would otherwise be prevalent in a convential job is minimized. Only one of these machines has been built, and the Allies, namely, France, Italy, and England, have divided up all the parts of the machine in three groups and are going to send them to their respective countries for study by their engineers.

DORNIER FLYING BOATS.

Mr. Dornier's flying boat design and construction are characterized by his lateral displacement fins that project out from the sides of the hull on all of his types. This obviates the necessity for wing tip floats, but, according to certain authorities who have witnessed the Dornier seaplanes getting off of rough water, it is very difficult to control them owing to the resistance of these displacement fins with the rough sea and the difficulty of maintaining lateral and directional control.

Mr. Dornier's duralumin floats are of very simple construction and follow quite well the conventional float type of construction with duralumin channel ribs and stringers in place of the conventional wooden ribs and stringers in ordinary wooden floats. The decking, sides, and bottom are entirely made of flat strips of duralumin, stiffened up with duralumin channel stringers. Mr. Dornier's style of all-metal construction seems to be very reasonable and logical throughout in the practical application of his idea. It presents no difficulty from a construction standpoint to any organization equipped and schooled in performing metal work.

SINGLE-ENGINE DORNIER PASSENGER AIRPLANE, COMET TYPE DO. C III, 1922.

The principal dimensions and characteristics are:

- Length, over all: 70.2 meters.
- Span: 17 meters.
- Chord: 3 meters.
- Maximum height: 2.7 meters.
- Wing area: 47 square meters.
- Engine, B. M. W., with tractor propeller: 185 horsepower.
- Fuel consumption—
  - With full speed—
    - Gasoline: 39 kilograms.
    - Oil: 2 kilograms.
  - With average speed—
    - Gasoline: 30 kilograms.
    - Oil: 2 kilograms.
- Weight, empty, including oil and cooling water: 1,250 kilograms.
- Weight, loaded, maximum: 2,000 kilograms.
- Maximum speed: 170 kilometers per hour.
- Average speed: 130 kilometers per hour.
- Maximum altitude with full load: about 5,000 meters.

With a different type of engine the performance of the machine will be varied. The machine is a monoplane without flying wires or braces, and like any other Dornier flying machine is constructed of metal throughout. All vital parts are of high-grade steel, while the body and other parts subjected to minor stresses are of duralumin. The wings are covered with removable duralumin sheets. If desired, fabric may be used for wing covering, whereby the carrying capacity of the machine is increased by about 80 kilograms.

The engine is easily accessible. Adjacent to the engine compartment, but separated by a partition, the saloon has been arranged, having accommodation for six passengers. This saloon may be boarded from the ground without the aid of a ladder. It is provided with every luxury which one would expect to find in a high-class touring car. The panoramic view to both sides is entirely unobstructed. Ample space for luggage has been provided. The pilot seat is forward of the cabin. He can overlook the entire engine.

Special attention has been devoted to the arrangement of the gasoline and oil storage. In order to reduce the danger from any fire, the gasoline tanks have been placed outside of the hull, so that gases can not penetrate into the interior of the machine. Any ignition of the gasoline tanks in case of carburetor fires is also provided against.

The construction of the machine is very plain and simple. There are no flying wires or braces. The factor of safety in the various parts of the machine has been assumed very high, and the entire machine is designed stout and square as possible. The average loading on the wings is low. Under full load it amounts to only 39 kilograms per square meter. The result is a short run on the ground for getting off and a low landing speed.

The landing gear is designed in an extremely simple fashion with a view to reducing the air resistance to a minimum, at the same time insuring greatest strength.

With a load of six passengers the machine can carry fuel for four hours at a high speed, this representing a range of about 600 kilometers.

The life of all-metal airplanes is very much longer than that of wooden machines. As there are no flying wires the wings will not warp. All parts are easily accessible and the covering of the wings is easily removable.

ZEPPELIN STAAKEN PLANES.

The Zeppelin Staaken plane is powered with 400-horsepower B. M. W. engines. The motors are installed along the leading edges of the wing. It was inspected at one of the Zeppelin plants just outside of Berlin. This machine has about 100-foot span and about a 13-foot chord. The motor mountings are very unique and of the cantilever type, extending out in truss fashion from the main duralumin box spars. Accessibility to the motors in flight is obtained by the mechanicians crawling out through manhole sections at the stiffening rib stations in these spars. The fuselage is about 10 feet deep at its master section and approximately 5½ feet wide. It is built entirely of duralumin, no steel being employed anywhere.

The landing gear is of the single, shock-absorbing leg and lateral stiffening V type, with two wheels on each side. The shock-absorbing leg terminates in the spar of the main wing.

The covering of the wings is entirely of duralumin. This machine is very much overweight in its construction and has a very high landing speed as a result. It is the first representative type, however, of a large, all-metal, internally braced monoplane and the lesson of the application of detail and assembly ideas has been far-reaching and valuable to other constructors. The wing construction, however, is entirely too expensive and too difficult as a manufacturing proposition.

Gasoline tanks are located toward the trailing edge of the wings and back of each power plant.

Another interesting Zeppelin Staaken plane is a smaller monoplane powered with 220-horsepower engines mounted on the leading edge. The arrangements are for two pilots

and six passengers. The useful load is about 2,200 pounds and it has a high speed of 110 miles an hour. It has a wing spread of 58 feet. Its radius of action is 400 miles. This machine was not allowed to be completed by the Allies, but it represents a very interesting all-metal construction, with characteristic Staaken single box spar principles instead of the conventional two-spar system in other machines.

Characteristics:

Span: 31 meters.
Total surface: 106 square meters.
Area of aileron: 33.80 meters.
Total length: 16.5 meters.
Total height: 3.30 meters.
Width of fuselage: 1.60 meters.
Weight, empty: 5,500 kilograms.
Total weight: 8,000 kilograms.
Useful load: 2,500 kilograms.
Power plant: 4 Maybach motors.

This machine in reality was 500 kilograms heavier than the original estimate. It has a high speed of 200 kilometers per hour.

JUNKERS CO.

Aeronautical activities at the Junkers plant, located at Dessau, have been greatly curtailed by the Interallied Control Commission. However, Doctor Junkers is endeavoring to derive commercial revenue through the development of duralumin rowboats, duralumin floats, Diesel engines, gas engines, stoves, kitchen ware, trunks, etc. He is pursuing aeronautical studies and carrying out wind-tunnel tests on various new designs. He intends to keep his organization intact, especially his experienced personnel, by turning over to them the construction of duralumin ware, which gives them an opportunity to keep in practice in the working with duralumin.

Doctor Junkers is designing a 700-horsepower aeronautical engine which is a radical departure from any orthodox type, the characteristics of which, however, were not divulged. Doctor Junkers is keeping it a secret until the motor has been perfected and has had satisfactory tests.

Doctor Junkers has a museum room in his plant in Dessau which contains all the milestones and physical stages of metal construction leading up to his present type. He has been thoroughly scientific and painstaking in the development of his all-metal construction. He has followed out his work logically with full knowledge of the properties of metals and has conducted exhaustive tests and experiments so that at the present time he is probably the best informed man on duralumin in the world. His advanced interpretation of all-duralumin construction, as is evidenced in his latest four-motored, internally braced monoplane, is a decided advance in the construction of large airplanes.

At present there are about 20 of the so-called JL–6 type of passenger-carrying Junkers monoplanes in the factory about 90 per cent completed. Authority to dispose of these machines has also been withheld by the Interallied Control Commission. Doctor Junkers designed and partially constructed a large, internally braced monoplane for four engines, either Mercedes, B. M. W., Maybach, or Liberty. The machine is capable of flying with its full flying load of 9,000 kilograms with three motors. With a flight load of approximately 7,000 kilograms the machine is capable of traveling with two motors.

The wings are of the characteristic Junkers tubular spar construction with plumber union type, screwed wing attachment fittings. However, instead of attaching the wings to nine spars as in the conventional JL–6 type, the wing proper, even though it is of the multiple spar type, is really trussed in the planes of the front and rear spars proper. The top and bottom spar flanges, so to speak, are made of duralumin tubes with cross-flange bracing of duralumin tubing. The whole wing is covered with corrugated duralumin covering. The machine has been designed for passenger carrying, but could be changed to a military load-carrying type if necessary. The fuselage structure is quite a departure from his conventional JL–6 fuselage type. It is triangular in sections and the aft end is detachable at the trailing edge of the wing. The truss is of the three-longeron type of duralumin tubes with Junkers screwed longeron joints. It is very easy to construct, maintain, and repair.

The landing gear is of the two-wheel type with shock absorbers in the leg of each V with practically the same principle as in the JL–6. The landing gear axle is hinged to the bottom of the fuselage. The motor nacelles stick out farther than the fuselage nose, thus obviating the danger, in case of a nose over, of bringing the fuselage in contact with the ground first. The ailerons and elevators are counterbalanced. There are three fixed fins and three rudders. Full detailed description will be sent to the engineering division at McCook Field.

A later projected model is of the twin-fuselage, four-motor, all-metal, monoplane type. This machine is to be powered with four 700-horsepower Junkers engines. The landing gear of this type is quite unique, inasmuch as the wheels and shock-absorbing units are entirely housed in the fuselage structure proper and the main wheels are located directly under the center of gravity of the machine. However, in order to obviate the danger of nosing over, which might be manifested with the wheels located so far back, two auxiliary wheels have been placed on the forward part of the fuselage beneath the nose forward of the center of gravity. This machine has a span of approximately 190 feet and the main chord of 35 feet, giving camber depth of wing of approximately 6 feet. From this it can be readily seen how easily adapted this wing is for carrying of bombs, fuel, or personnel. It represents the best evidence of a streamlined bombardment machine that has been projected in Europe to date.

MAYBACH MOTOR COMPANY.

The Maybach Motor Co. is situated in Frederichshafen. At present they are not engaged in any aircraft-motor work, but are devoting their energies to the design and construction of motor cars. Mr. Maybach stated his preference for 12-cylinder dirigible engines, and according to information he has designed one which he will build at the first opportunity.

The Maybach 6-cylinder war-time dirigible water-cooled power plant is conceded by French engineers and Italian authorities to be the best dirigible engine developed in the world to date. Characteristics of this engine are included in the Maybach handbook on this type, which has been obtained for our engineering division.

REPORT ON B. M. W. MOTOR.

Mr. Stephan, chief engineer of the Dutch Air Service, made an exhaustive study of the Fokker airplanes equipped with the B. M. W. motor. As a supplement to this report, he attached a study on the B. M. W. motor which is considered worth while.

His study is quoted in its entirety, as the B. M. W. was one of the most extensively used motors in Germany.

Motor type.—The 185-horsepower B. M. W. high-altitude motor (200-horsepower Bayern motor) is well known and needs no description. Perhaps some interest will be attached to the service results with these motors.

Overhaul routine.—In the Dutch Air Service the rule for these motors is: Overhaul after 80 flying hours, liable to an extension, after inspection by the controlling engineer, of 20 hours, giving 100 hours absolute maximum.

The overhaul is a complete one, not a top overhaul.

Some of the motors have had four overhauls now and are near their fifth.

With good care and plenty of spare parts to be used at overhauls it will be possible to prolong their life as reliable motors for quite an appreciable period.

As yet no definite conclusions as to their ultimate life have been reached.

Difference of make.—The Dutch Air Service received two series of B. M. W. motors. Part of them were from the original works (Bayerische Motoren Worke, Munchen), the others had been built in license at the Opel Motorworke (Busselsheim). Apart from the construction of the connecting rods, the cam shaft, valve timing, and some minor details, the construction of both engines is identical. The workmanship and finish of the original B. M. W., however, is far better than that of the Opel-B. M. W. Some of the difficulties which were experienced with these motors appeared only with the Opel-B. M. W. and not with the original B. M. W., while other difficulties of which both types suffered generally appeared earlier in the Opel-B. M. W. than in the original B. M. W. The original B. M. W. motor is superior in every respect to the Opel-license-B. M. W. motor.

Service results.—The exceedingly high compression ratio of these motors occasioned some trouble in the first service period, during which ordinary petrol (gasoline) was used. Although the high-compression ratio (6.55:1) does not give rise to its normally equivalent end pressure, as the high-altitude carburetor does not permit full admission at low altitudes and the gas is thus throttled to a large extent at low-altitude full-power runs, it was found that with petrol as fuel the compression was still too high. No type of spark plug could withstand the abnormally vehement explosions.

Ricardo's well-known experiments on various fuels for aviation engines formed an inducement to change the fuel for one with a high "toluene value." A mixture of benzol and petrol in proportion of 60:40, using benzol with a high toluene percentage gave very good results and was adopted as a standard fuel.

The physical properties of the benzol used were as follows:

Sp. W.=0.86.

Freezing point: From −20° C. to −35° C.

Distillation range: From 80 or 85° C. to 110 or 120° C. for 95 per cent. (About 60 per cent beneath 100° C.)

No compression troubles occurred since then.

The ignition in these motors is by means of two Bosch Z. H. 6–'14 magnetos which are a special lightened type of aviation magneto. These proved inadequate. In the Dutch Air Service the normal Bosch Z. H. 6 magneto is mounted instead.

Apart from this it was found that the magneto mounting was badly designed so that another type of mount was substituted.

Of the different failures and other difficulties observed with these motors perhaps the most interesting are cracks in the cylinder flanges.

In the Opel-B. M. W. motor the corner between this flange and the cylinder wall is not rounded off sufficiently, the radius of the fillet being practically nil.

There is nothing remarkable in the fact that such a faulty form leads to fractures, but it is certainly remarkable that in a factory with the experience of the Opel Works such a source of failure can pass unobserved in a complete series of motors.

It is worth note that the fractures occur specially in the first and sixth cylinders, these being the cylinders which get most of the vibration. The cam shaft fixes the other cylinders. The failures are pure fatigue fractures.

The pistons and gudgeon pins are a further source of trouble. Incorporated in the aluminum pistons are cast-iron bushes (the gudgeon-pin housing being cast integral with the piston) in which the gudgeon pin rests. At the slightest amount of play between gudgeon pin and cast-iron bush, these bushes work loose in the piston bosses, and as it is impossible to change these bushes this is a great drawback.

It was necessary to keep a large amount of specially made gudgeon pins in stock with a diameter one-tenth of a millimeter bigger than the original ones. When at an overhaul gudgeon pins are found to fit too loosely in their bushes, these are ground to measure for new pins to be fitted. Possibly in the long run it will be necessary to repeat this system of replacement by slightly bigger pins.

In a similar manner an analogous trouble with the floating bushes of the connecting rod is overcome by keeping in stock specially made bushes with three-tenths of a millimeter more external diameter.

Far too much disparity was found to exist between the pistons of the whole series to permit of complete interchangeability. A strict selection must be made so that the amount of piston play is correct.

The valve mechanism has not given much trouble. Often cam rollers must be replaced owing to inequal wear or play in the roller axles. The rocking lever axles develop play in their bearings, which are simply reamed in the upper and lower half of the cam-shaft covers, of which the lower half is forged steel, while the top cover is aluminum.

In service this necessitates replacement of these covers, as adjustment of these bearings is limited by the amount of room between rocking lever and top of cover.

Sometimes valves guides had to be renewed.

The very peculiar valve timing of the Opel-B. M. W., differing from that of the original B. M. W., is worthy of note.

Whereas the original B. M. W. has approximately:

Inlet opens 5° E.
Inlet closes 37.5° L.
Exhaust opens 52° E.
Exhaust closes 19.5° L.

with individual differences.

The Opel-B. M. W. shows the following setting:

Inlet opens 14° E.
Inlet closes 63° L.
Exhaust opens 55° E.
Exhaust closes 25° L.

with large individual differences.

This extraordinary valve timing reduces still further the already low fuel consumption so that with these motors a fuel consumption of 180 grams per metric horsepower, equal to 0.4 pound per horsepower at full-power ground runs, is regularly obtained. The maximum power output is also slightly reduced as against that of the original B. M. W., but not in the same proportion.

The oiling system gave some trouble with the cam shaft lubrication. This is taken from the front crank shaft journal bearing through an extremely small hole in a nipple and was often insufficient. After changing this by taking the oil supply for the cam shaft direct from the main oil lead in the center through a calibrated jet in a nipple no further difficulties were experienced.

Defects in the oil pumps occur occasionally.

In the cooling system some difficulty is encountered by leaky water pumps. It is often necessary to change the bronze bearing of the pump shaft, especially those directly behind the vane. The water jackets of the cylinders sometimes spring leaks. In the original construction the oil tank was suspended from the cylinders by fixing it to bosses welded on the water jackets, and this frequently occasioned leaks. After changing the suspension of the oil tanks the frequency of water-jacket leaks has been greatly reduced.

The carburetor is rather sensitive for changes in fuel, but is exceedingly good. Attention must be paid to securing the jets, which are apt to get astray. Renewal of the axles of the float chamber rocking levers is often needed.

Care must be taken that the float room cover is well in place.

Renewal of the chief bevel wheel on the crank shaft, owing to its working loose on the key and developing hair cracks, was sometimes necessary, and a good deal of attention must be paid to the vertical transmission shaft. The ball bearings of this shaft often work loose in their housing, a difficulty which is remedied by fitting bronze cages.

Conclusion.—Notwithstanding these difficulties the general impression is that the motor is a very fine specimen of what Germany could produce at the end of the war. It is purely a war motor of sound design but suffering from a few minor faults, partly attributable to wartime material and partly to design, but all of them of small importance. The B. M. W. is a high-altitude motor "par excellence," and should be used as such, and is, therefore, not a motor to be recommended for commercial traffic purposes.

In this respect it may be of interest to note that the B. M. W. motors which are used for the school machines (C–I with dual controls), referred to in the report on the Fokker airplanes, which are never used at high altitudes, have had their compression ratio lowered by 3 millimeter rings under the cylinders.

HOLLAND.

FOKKER AIRPLANES.

The only aeronautical designing and engineering plant in Holland is the Fokker Co. Mr. Fokker has reestablished himself with the Dutch Government and has procured adequate facilities for experimental and development work. In treating Fokker airplanes a brief description will be given of the various types in comparison with the well-known D–VII and this will be supplemented by the very complete report of the Dutch Air Service stating what their experience has been with the standard Fokker type planes through 11,000 hours of flying.

Fokker types are as follows:

(1) Fokker D–VIII: 130-horsepower Oberursl rotary engine pursuit monoplane.

(2) Fokker D–VII: Pursuit biplane.

(3) Fokker F–III: Commercial internally braced monoplane, single-engine job, 260-horsepower engine, carrying 5 people.

(4) Fokker F–IV: Internally braced monoplane with Liberty engine, carrying 10 people.

(5) Fokker V–XL: Internally braced, 300-horsepower Hispano monoplane, armored and unarmored.

(6) Fokker United States Navy torpedo seaplane, with Liberty engine, internally braced monoplane type, twin floats.

(7) Fokker two-seater observation, Liberty motored biplane.

(8) New Fokker 300-horsepower Hispano pursuit biplane, internally braced.

The first five machines are very well known to us, as we have procured one of each of these models to date in this country. This obviates the necessity of describing them.

FOKKER UNITED STATES NAVY TORPEDO SEAPLANE.

The Fokker United States Navy torpedo-carrying seaplane is an internally braced monoplane with veneer covered wings. The wings extend out from the bottom of the fuselage in Junker fashion. The wings are built in an integral unit, fastened from underneath with six bolts, as in the characteristic bottom wing fastening of the D–VII type. The wing tips outside the float support stations are removable.

The tail unit and fuselage are of characteristic Fokker type detail construction. All the control surfaces are counterblanced.

This machine is fitted with two Brandenberg type of seaplane floats. These are of all-wood construction, with steel float tubes braced to the lower side of the wing and the fuselage. This machine has been fitted with the Liberty low-compression navy engine.

It weighs, completely loaded, about 5,200 pounds and has been designed to carry a 1,650-pound torpedo.

The machine is representative as to type, and has been very well designed and constructed for visibility and for defensive armament installation. The gunner-observer's cockpit is situated immediately behind and in close proximity with the pilot's cockpit. The observer's cockpit is extended far enough underneath to permit the use of machine-gun fire underneath the fuselage. The Navy will soon receive delivery on this ship.

FOKKER LIBERTY MOTORED OBSERVATION PLANE.

The Fokker Liberty motored two-seater observation plane is really a geometrically similar type to the Fokker D–VII on an enlarged scale. The power plant is equipped with a nose radiator. The oil tank is placed directly in the rear of the engine in the fuselage on a level with the oil pump. The gasoline tanks can be disposed in the fuselage, wings, or landing gear. If the gasoline tank is in the fuselage, it is placed directly in front of the pilot, between him and the engine. The gunner-observer is immediately back of the pilot. The two cockpits are very close together, as in the DH–4B and XB1–A types. The landing gear is of the conventional Fokker welded steel tube type, with the auxiliary gasoline tank built into it.

The fuselage construction is of the conventional Fokker welded steel tube type. It has been very carefully and thoughtfully executed, always having in mind production, ease of maintenance, and accessibility throughout. Provision for the adaptability in both cockpits of military equipment has been very carefully thought out.

The tail unit is practically the same as the D–VII in design, although it is simpler to assemble. Tail skid springs are fitted as a shock-absorbing medium to the tail skid proper.

The bottom wing has about 25 per cent less chord, although of practically the same span as the upper wing. The total area of this machine is approximately 380 square feet. The main wing rigging truss is identical with the D–VII. This machine could be very well adapted, with few modifications, to meet our observation type requirements, and from a standpoint of accessibility, maintenance, and ease of manufacture, it is epecially well suited to our requirements. It is the best machine with Liberty engine that is to be found in Europe.

This machine completely loaded weighs about 4,390 pounds, with useful load of about 1,530 pounds, which includes five hours' fuel supply. By a change in its present cooling system, it could very easily be fitted with a supercharger.

The wings, fuselage, and tail unit of this machine are covered with fabric identically the same as the D–VII.

All control surfaces are counterbalanced.

FOKKER 300 PURSUIT.

The new Fokker 300-horsepower Hispano, single-seater, pursuit is a machine geometrically similar to the Fokker D–VII in its entirety. It will weigh approximately 2,700

pounds fully loaded, and will have an area of about 290 square feet. This machine is now in the course of construction and ought to be completed soon. As it will be delivered to our engineering division, detailed description is unnecessary.

Three days previous to a flight with Mr. Fokker in his new naval torpedo-carrying job he had sawed off about 3 feet of the fuselage stern, thus shortening it by that amount, and had moved the complete empennage forward in the same measure. This was entirely done within three days' time. Mr. Fokker stated that the tail of the machine as originally conceived was too long and that it was not quite as maneuverable fore and aft as he wished to have it. In the following flight he ascertained the degree of maneuverability and control that this disposition of the tail had given the machine and he was entirely satisfied and stated that it had shown a marked improvement. Mr. Fokker's success in building aircraft is largely due to his ability as a pilot and his first-hand knowledge of the desirable characteristics of control and stability in any type concerned. This ability to test any type and to recognize and rectify immediately the control system fault throughout is invaluable. His direct control over his factory and over his business, his large amount of first-hand knowledge and experience with all different types, plus his ability to pilot and test out his own types, gives him a decided advantage over most modern designers.

In a large measure, our own lack of success in the immediate solution of controlability problems has been due to the fact that designers have not ascertained the feel of the machine from a pilot's standpoint, and thus have to engage themselves with empirical values derived from control surface coefficients, averaged up from all the various types in general use, supplemented by the opinions of pilots who have flown their various types.

Unless one flies, this is the only natural method of ascertaining this data because our knowledge of control surface design from a standpoint of scientific aerodynamical data is not reliable enough for practical application and is too involved to give satisfactory results. In other words, our methods in designing control surfaces have been really rule of thumb while Mr. Fokker has used the cut and try system until he procured what he desired.

On the whole, approximately 8,000 Fokker machines have been built to date, and no master criticisms have been made against his type of construction by European designers except in prejudical fashion. These were directly attributable to lack of experience with his methods. The ease with which any or all of his aircraft can be repaired or maintained has never been surpassed by any other type.

The simplicity of the application of his detailed structural ideas throughout all his types eliminates any complicated fittings and has contributed largely toward aiding Mr. Fokker and his organization to bring out new types very quickly.

Mr. Fokker has made trials with the landing gear gasoline tank set on fire and claims to have had very satisfactory results. There was no flame injury to the rest of the machine. He claims that installing the tank in the landing gear has been the most satisfactory method for protecting the pilot and machine in case of fire. Inasmuch as the flame begins at the burning gasoline tank, it will be immediately blown back by the action of the slipstream. It is out at such a distance from any inflammable portion of the aircraft, and is so insulated by cool air stream between the tank and wings or fuselage of the craft, that danger from fire is minimized. Mr. Fokker claims this is a better installation in practice than a detachable gasoline tank.

MAINTENANCE OF FOKKER AIRPLANES IN GENERAL SERVICE.

(Cantilever wing type and welded steel fuselage.)

(Prepared by the chief engineer (technical service) of the Dutch Military Flying Corps. March, 1922.)

DUTCH AIR SERVICE REPORT ON THE FOKKER AIRPLANES.

The chief engineer of the Dutch Air Service promised to prepare and forward a complete report of the performance of the Fokker airplanes used by that country. This report is so interesting that it is given in its entirety.

It is desired to give full credit to P. W. Stephan, chief engineer of the Dutch Air Service, for all data in this section of the report. The report follows.

GENERAL DATA.

In the course of the summer of 1920 (May–September) the two series of Fokker airplanes with which this report deals (D-VII scouts and C-I reconnaissance machines) were delivered to the Dutch Military Flying Corps (Luchtvaartafdeeling).

The construction of these airplanes differs from the more orthodox design in that the wings are of cantilever type, and the whole of the fuselage, the tail planes and rudders, the wing struts and the central wing fittings are constructed of welded steel tubes. The reconnaissance type carries its petrol tanks in the landing chassis.

The mistrust felt in some quarters against cantilever wings in general is so unfounded and denotes such a lack of knowledge of the stresses to be considered that we may regard it as a thing of the past.

Reflections of this kind were not considered when the order for these airplanes was given, but of course the contract stipulated various static tests. The actual strength in all cases (direct wing loading and wing torsion) was far beyond the requirements.

A certain amount of distrust is still felt in many quarters against autogenous steel welding in airplanes, specially when the welded parts come in traction.

In the Dutch Military Flying Corps, however, through a two years' experience with a small series of Fokker D-VIII, Gnome-Oberursel 160-horsepower scouts, which had a fuselage of welded steel tubes, sufficient confidence in this system of fuselage construction has been gained to warrant an order for a larger series of similarly constructed machines. That this confidence was not ill-placed was proven by subsequent events as described in this report.

The types of machines are both well known, the Fokker D-VII being generally much appreciated by pilots (a couple of these machines had been in use at Soesterberg since 1918), while the C-I was a new design brought out

since the armistice and the first two-seater reconnaissance machine designed at the Fokker works. This type had not been built in series and the Dutch Military Flying Force received the first series of these machines.

Both airplanes have the same motor, B. M. W. altitude type, 185 horsepower nominal (B. H. P.: 200 at normal number of revolutions: 1,400 revolutions per minute).

At Soesterberg some of the scouts are equipped with a Mercedes, high-compression, oversized, 180-horsepower motor.

ACTUAL FLYING TIME ON WHICH THIS REPORT IS BASED.

At the moment at which this report is compiled, according to the log books these machines have an actual flying time of 11,000 hours (10,868 hours and 30 minutes).

During this time not a single fatal accident occurred, while only in one instance, caused by stunting at low altitude—injury of a more or less serious character, severe face wounds—resulted to the pilot. (Machine damaged beyond repair.)

Other accidents, though sometimes considerably damaging the machine, did not result in injuries of any seriousness to the occupants. It must be kept in mind that Holland is one of the worst possible countries for forced landings owing to the smallness of the fields and the great number of dikes intersecting them. Nearly all accidents resulting in material damage were caused through landings ending in a ditch.

Of the 11,000 actual flying hours, only 850 hours were flown in scouts (D-VII), these machines being kept in reserve so that only a few of them are used for practice, etc.

The C-I reconnaissance machines, therefore, have had about 10,000 flying hours. Unless stated otherwise, the remarks in this report apply specially to the C-I airplane.

The number of C-I machines in actual use varied from 30 to 35, the remainder being kept in stock or being in course of repair or revision.

The C-I machine with the largest number of flying hours in actual use has 380 hours to its credit (two overhauls).

OVERHAUL ROUTINE.

In the Dutch Military Flying Force every airplane is subject to a complete overhaul in the workshops after 150 actual flying hours. In special cases this period may be lengthened after inspection by the controlling engineer to an absolute maximum of 200 hours, but the rule is revision after 150 hours. On an average every machine makes in this period between overhaul some 230 flights with landings.

For school machines (some of the Fokker C-I machines are equipped with dual control for instructional purposes) the rule is inspection and overhaul after 400 landings or 100 hours. This is liable to a possible extension to 150 hours maximum. On an average these machines have now each some 680 landings to their credit.

GENERAL FLYING SERVICE RESULTS.

Both types of machines have given full satisfaction in a general way. The Fokker D-VII is so well known that no further remarks as to its performance, strength, etc., are needed.

The Fokker C-I has proved itself a fairly good reconnaissance machine. Its speed is rather low, but its lifting power, rate of climb, and general maneuverability are quite sufficient.

Weight, empty: 1,900 pounds.

Contract load—petrol, oil, and military load: 794 pounds.

Maximum speed at ground level with contract load: 110 miles per hour.

Rate of climb fully loaded to 5,000 meters (16,400 feet): 21 minutes.

The ailerons are rather small, making the machines somewhat sluggish in maneuvering. Apart from this, controllability is very good and the machine is light on controls. The C-I stunts well, as does the D-VII, but good rolls and even half rolls are rather difficult to perform with the former.

The petrol tanks in the landing chassis have no disagreeable effect, either in flying or landing. The machine, though easy to land when the pilot is accustomed to it, is rather delicate in landing across wind.

A very good feature of the machine is that it may be stalled with impunity, there being no tendency to slip down on one wing or to nose-dive out of a stall.

In the Dutch Military Flying Force the C-I has been used as a general-purpose machine, being equipped either for camera work (fixed cameras and cinematograph cameras), for artillery observation, or for light bombing.

For bombing purposes some difficulty was encountered with the bulky petrol tanks in the landing chassis which obstructed the view to a large extent. Ultimately this difficulty was overcome by changing the position of the bomb-sight telescope.

The observer's cockpit is not very roomy and the observer, when on general reconnaissance work, is rather cramped between camera, wireless apparatus, etc. There is no accommodation for parachutes.

GENERAL TECHNICAL RESULTS.

In comparisn to other machines the Fokker airplanes have been strikingly successful. Bearing in mind that the C-I as used was a first production, one may say that it showed very few of the troubles generally inherent in a new type.

The only trouble worth mentioning in this respect was given by the undercarriage. Both the chassis itself and the wheels were rather weak. This was specially so for the very hard sand, gravel, and heather surface of the Soesterberg aerodrome. The tanks gave some trouble, too. The landing chassis was altered and reinforced, as described later on, and other wheels were mounted.

The tail skid and its fittings were not sufficiently strong, and the skid should have had some more lateral play, as it occasioned in some cases torsion of the tail where sharp turns on the ground had been made.

An interesting fact is the comparatively large amount of distortion which the steel tube fuselage will take without any externally visible deformation or loosening of wires. Instances occurred where a machine developed a tendency toward tail heaviness without any apparent cause. A careful investigation of the fuselage structure, fixed in a trestle specially designed for the purpose, showed that although all the wires were still in tension

and the fuselage appeared all right, yet the tail plane was as much as 1½ inches out of line. By simply tightening or loosening wires, keeping them all the while in tension, very appreciable deformation can be obtained. Sometimes a vertical shifting of the tail-plane fittings over 2½ inches was obtained.

All fuselages when overhauled are now checked as to their being in line, while the wire tension is noted also.

There are three predominant factors when judging the relative merits of steel tube structures as used in Fokkers against the more orthodox constructional type of trussed fuselages with wooden longerons and wooden struts or wood and ply-wood monocoque fuselages.

In an article in Het Vliegveld of March, 1922, Mr. Takens, technical officer, R. D. N., attached to the military flying corps as works engineer, draws attention to these points:

First. Simplicity of overhaul and repairs.

Second. General accessibility.

Third. Damage done to machine and danger to pilots in crashes.

The steel tube construction scores under all three headings.

First. Nothing could be simpler than the overhaul of a steel fuselage. After stripping it of its fabric the naked structure is open to inspection from all sides.

It is easily cleaned or checked as to its being in line, repainted, and ready for use again. Compare this with the overhaul of a wood and ply-wood fuselage, all soiled and soaked by oil which has weakened the wood and deteriorated the ply wood. Every cross-strut socket and fitting should be inspected, which is only possible by stripping part of the fuselage of its ply-wood covering. In monocoque construction the inspection of the internal structure is even more difficult than in braced girder fuselage construction.

As to the facility of repairs, this will be dealt with later on, but it is certainly better than with most of the ordinary wood construction.

Second. The accessibility of the fuselage structure itself is far better than in most other constructions, but more important still is the engine accessibility which this type of construction affords. This is best illustrated by comparing a Fokker and a DH-9, both without motor cowling, made as accessible as possible. In the Fokker the different cowl sheets, fixed by wing nuts, are taken off without more ado, leaving the engine perfectly free.

Magnetos, oil, and water pump are all of them accessible.

In the other machine it has, first of all, been necessary to remove the air screw in order to get at the front engine cowl, and even then the accessibility, specially of magnetos, oil, and water pump, is not half so good as in the Fokker.

Third. Provided suitable materials are used and the tubes are not brittle, it is quite astonishing to see what distortion in crashes can take place with Fokker fuselages without any direct fracture.

It certainly is no bold assertion when it is stated that when a machine lands in too small a field with full flying speed, completely wrecking its undercarriage in a ditch and turning a somersault, ordinary wooden construction would be reduced to smithereens, while the occupants might reckon themselves lucky if their injuries were only slight.

In all accidents to Fokker machines the cockpits did not suffer. Even in the case in which a pilot lost his way at night and struck the earth in a ground mist during his downward glide before flattening out, thus diving, as it were, right into the very hard airdrome soil, the pilot escaped without a scratch, although the machine was a complete "washout."

In a report of the Dutch National Aeronautical Research Laboratory on tests on the strength of fuselages composed of seamless steel pipes joined by autogenous welding, which will be referred to later on, special attention is drawn to this significant fact, which contributes greatly to the safety of the occupants and which may be ascribed to the large amount of shock absorbed by the deformation of the steel members in the front and bottom of the machine.

From a maintenance viewpoint this fact means, moreover, that the result of even the worst crashes is more or less local, so that repairs are not so extensive as in the case of wooden machines.

This applies also to the wings, whose box spars are of exceptional strength and therefore suffer but little in most crashes.

An observation which affects operation as much as maintenance may be made with reference to the rigging and dismantling of the airplanes. The removal of the wings is done in less than a quarter of an hour. The rigging is an exceedingly simple job and in no way comparable to the rigging of a machine with ordinary wings.

STRUCTURAL MATERIALS.

Not all the materials used in these machines come up to English or American standard specifications. Still they have given ample proof of being satisfactory for the purposes for which they are used.

Without going into a detailed analysis of these materials, some insight into their properties can be gained from the following general data from tests taken with test pieces made out of the finished parts:

Material.	Tensile strength in tons (of 2,240 pounds) per square inch.	Elongation in per cent.
(a) Steel tubes	28.6- 44	13- 7
(b) Sheet steel for lugs, wing fittings, etc	28.6- 31.1	25-10
(c) Steel bolts (high stresses)	60 - 66	8
(d) Other steel bolts	39 - 61.4	15- 8
(e) Steel for turnbuckles or strainers	42 - 57.1	8- 6
(f) Steel wire (bracing wire)	119.3-188.4	7- 3

(a) Although the elongation is rather small, these tubes will take a great deformation. They invariably conform to the compression test.

The autogenous welding of these thin tubes is a job which requires well-trained men; but under the assumption that the work is done by men equal to their task, it is safe to assume that the welded parts are reliable.

The interesting report of the Dutch Aeronautical Research Laboratory concludes: Autogenous welded joints of seamless tubes (oxygen-acetylene welding), if well carried out, are as reliable as other metal joints or con-

nections. When inspecting a cut through a joint, little defects are ever found. When these are not too large in extent and the crystallization of the two parts that meet in the joint is continual, these defects have no appreciable influence on the strength.

The parts of the tube next to the joint are annealed by the heat of the flame. The elastic limit in these parts is lowered, so that deformation begins there.

(b) This material has not given rise to any remarks. The wing fittings of the Fokker are lightened by holes. It was found that in some of the fittings these holes had been punched instead of having been drilled, thus occasioning small hair cracks starting from the punched holes. These fittings were rejected and only drilled ones accepted.

(c) and (d) In a couple of instances small bolts were found too brittle. In all cases these were tail-plane bolts and subject to vibration.

By lightly annealing these bolts the elastic limit could be lowered without impairing the breaking strength to a dangerous degree, thus giving a higher percentage of elongation.

(e) As the test pieces were made out of the finished parts, they were perforce rather small, and the elongation numbers are therefore not quite reliable.

All turnbuckles, however, stood the double-bending test.

The other materials used do not call for comment. The wing construction follows the same lines as that of the D-VII, which has been amply described. The box spars are built up of an upper and bottom laminated beam of rather low-grade fir strips glued together, with webs of birch ply wood, the whole being covered with fabric, doped, and varnished. In between the top and bottom flanges are glued reinforcing wood blocks at different intervals, the whole following the usual Fokker practice. A special note may be made of the exceedingly efficient cold glue used in these airplanes.

In the Dutch Air Service the "Luward" cold glue (Schütte-Lanz) is used and found to be both excellent and easy to handle.

The ribs are of the same pattern as in the D-VII; the curvature of the leading edge is maintained between the ribs by a veneer layer cut away in triangular fashion and fixed on ribs and spars.

The fabric originally used is a linen fabric of about 80 to 87 pounds per inch strength in warp and weft.

STRUCTURAL COMPONENTS.

Fuselage.—The fuselage is a very sound job as a whole and has given few difficulties.

The only points worth note are:

First. The transverse bulkhead in the motor frame which interconnects the front landing chassis fittings was too weak.

After long service a small ridge developed in the tubes as a result of compression caused by landing shocks.

All machines were therefore altered by additional braces welded to points other than original welds. This form of reinforcement was chosen because the simpler way of using a simple T structure would lead to renewed welding in the middle section of the original construction, which would be weakened thereby.

Second. The cups of the landing chassis fittings were welded in a better fashion than in the original construction because they gave way too quickly.

Third. To obviate the difficulty of the tail skid twisting the frame at the tail, it was found necessary to strengthen this part. It would have been better perhaps to change the place of the tail skid itself, giving it more lateral play, thus taking away the cause of the difficulty, but as this would have necessitated far more work it was thought sufficient to strengthen this part. Two methods were used. The simpler one, consisting of replacing the original 24 by 1 millimeter vertical tube by a 28 by 2.4 millimeter tube, giving not only increased strength against torsion but slightly strengthening the whole tail by the greater circumference that can be directly welded in the V of the main girders. This has proved satisfactory.

A stronger type of tail skid than that originally mounted is now being used also.

An interesting point to be considered is the ease with which major repairs can be carried out. Entire tubes can be replaced and welded in the old fuselage.

The report of the Dutch National Aeronautical Research Laboratory may be quoted as to the best way in which such parts can be welded.

In tensile tests of tubes welded together, with an inner tube as reinforcement, the failure occurred at the outer edge of the inner reinforcing tube, while the total strength of a tube welded in this fashion was greater than that of the original tube. In tests where the inner tube had been fixed by spot welding to the outer tube the failure occurred at a lower maximum stress. Probably this is caused by the annealing action of the welding flame in the neighborhood of the spot weld.

As a rule an inner tube makes the joint more reliable. If it is desired to make it more reliable still by spot welding, then the spot welds must be placed at such a distance from the end of the inner tube that the original material is not weakened by annealing.

In the Dutch Air Service all joints necessary for repairs are made in this fashion, with this restriction, that in cases where the tubes come in tension the butt joint of the outer tubes is made perpendicular to the tube axis, while in cases where the tubes come in compression the joint is made at an angle to the axis. The reason for this is that as failures never occur in the joint but always next to it at a place where the material is annealed by the heat action of the flame, compression struts come in a better condition when this annealed area is not perpendicular to the axis.

If these rules are observed and good welders accustomed to the welding of thin tubes are employed, the repairs are easy and reliable. Of course difficult points require rigid inspection, as was shown in one instance where at the triple joint of the wing-fixing pyramid a hair crack was discovered starting from the small transverse tube. It was found that the joint had been carelessly made and part of the material was burned.

In the Dutch Air Service an inner tube is inserted in the central tube of this pyramid.

It is therefore recommended not to paint such difficult points but to scratch (or lightly sand-blast) them bright and then to varnish them with a transparent varnish.

A point worthy of note in this respect (ease of repairs) is the simplicity of the workshop equipment when compared to what is necessary for the repair of wooden machines. Practically the only equipment needed for fuselage repairs is a good, movable welding plant and a supply of tubes of different sizes. When repairing wooden machines one needs, on the contrary, wood machinery for the machining of struts, longerons, spars, etc., and if no complete stock of fittings, etc., is at hand, the manufacture of these parts is another laborious job, necessitating at least a die press.

These facts are particularly important in time of war when the necessity arises of having repair shops in the field behind the front line. Quite elaborate repairs to steel tube fuselages are then possible, whereas elaborate repairs can not be carried out with wooden fuselage.

TAIL UNIT.

The tail unit, which is identical with that of the D-VII, has not given rise to any trouble. As stated above, a couple of tail-plane bolts failed in use. From then onward all bolts were lightly annealed. As a further safety measure, intended to eliminate dangerous results in case such a fracture might occur again, a simple fitting was designed and mounted on all machines, serving to prevent the doubling-up of part of the tail plane in case of failure of a bolt during flight. It must be pointed out, however, that there has not been an occasion to prove the usefulness of this fitting now that better bolts are used.

LANDING CHASSIS.

The landing gear was the only part of the C-I planes that was inadequate.

As it has a double function, being a landing chassis as well as a frame for carrying the petrol tanks, the different difficulties will be treated separately.

(*a*) *Petrol tanks.*—The general form of this tank is good and the difficulties are only a result of faulty design and improper workmanship. The tank is divided in two by a partition, one part being the chief tank, the other forming an auxiliary tank. As both tanks are pressure tanks, the tank walls are under pressure and the flat partition between the two tanks is not sufficiently strong to withstand pressure combined with shocks from petrol knocking against one side when the other tank is empty. Frequent leaks are the result and, this partition being absolutely inaccessible, repairs are difficult. Of course such leaks only amount to the two tanks serving as one and do not incapacitate the machine.

The soldered seams of the tank are not strong enough. These seams should have been riveted or flanged in some way and then soldered. In the first service period, before the tanks were overhauled, leaks were rather frequent and different forced landings were caused by loss of pressure through leaks, either at the seams or at the joints of the filler cup.

The secondary difficulty was that the ply-wood cover, streamlining the tank, had to be demolished in order to get at the tank for repairs. These streamline fairings were, therefore, altered and made in two parts.

(*b*) *Landing gear.*—The difficulties in this respect started with the axles. These were rather thin (55 by 2.6 millimeters), and as the slots in which the axle moves vertically were not lubricated sufficiently, the axle wore very quickly at the critical point and, in a few instances, gave way. Heavier axles (55 by 5 millimeters) were mounted and more attention was given to lubrication of the axle slots in the chassis.

The next difficulty was that there was too much lateral play of the axle. This caused broken wheels, because the shock-absorber hands came in contact with the wheel spokes. Distance rings were mounted, thus doing away with this difficulty.

The shock-absorber hands, consisting of two short tubes welded to the chassis and ending in a small flange, were too weak. These were reinforced by mounting an inner tube in each.

The wheels were too small and rather weak. They were replaced by bigger and stronger wheels.

The diagonal bracing cables in the chassis were fixed to the struts by small welded lugs. As soon as extra stress came on the cables through hard landings, the small welded lugs were torn out of the strut. The joint itself never failed, but the lug was torn out bodily with the joint and a strip of the tube.

All chassis were altered and reinforced.

Taking everything together, the original landing gear was decidedly too weak and even in its altered form is far from being ideal.

WINGS.

The wings are of astonishing strength, especially in crashes, and are exceedingly simple in repairs. Even in the worst accidents it is an exception to find a broken spar which can not be repaired with very little trouble. If spars show a fracture after a crash, it generally is in the thinnest part of the wing tips and is occasioned by the crushing of the wing tip in striking the earth. Such fractures, which are rare, are easily repaired by making simple splices in the top and bottom beams, staggering the scarfs according to the laminations, and fixing new ply-wood webs over a greater area than that limited by the splice.

The following difficulties were experienced with the wing construction:

The internal bracing is badly designed. The bracing wires attack the spars at their weakest end where there is no strut or compression rib to take the resultant stress. It is obvious that this faulty arrangement leads to spar deflections at the points where the lugs are attached. These deflections were often of the magnitude of 6 millimeters and more.

As this result was discovered at the overhaul when the spars were already deformed, it could not be remedied by simply fitting a strut or compression rib. Therefore a thick three-ply panel reinforced by two triangular glued struts was fixed between the spars at this place.

The designer of the machine proffered the opinion that this internal bracing is not needed as a drift truss, because the wing is strong enough without it, but that it serves more to keep the spars in place during assembling, an assertion which must be taken "cum grano salis."

Though there are no real compression ribs in the drag truss, still there are some double extra strong ribs, intended to serve as compression ribs.

That a better drift bracing is needed is shown also in the behavior of these ribs. In the lower plane the webs of the innermost reinforced ribs have a tendency to buckle up. This has been remedied.

A further point noteworthy in this respect is that the wing spar fittings, especially of the lower wing, develop a little play after long service. This play sometimes amounts to 2 millimeters and is taken up by inserting small flat wedges between fitting and spar.

A quite unimportant alteration made in the Dutch Air Service is the half rib which was put in the wing near the fuselage because the veneer layer in this place suffered too much at the hands (and feet) of mechanics.

It was found that most wings did not need new fabric at their first overhaul. Therefore the fabric is often only loosened at the points needing inspection and then repaired. After this all the paint is removed by a solution that does not attack the dope. The wing is then redoped and repainted with a pigmented dope covering. Treated in this way the fabric can generally stand 300 hours and more. The wing is then completely stripped and covered with new fabric at its second overhaul.

In a few upper wings, for no apparent reason, the fabric at the top was torn loose from a couple of ribs. As this happened only at a place where there is an inspection and entrance hole for the aileron control cables in the lower surface of the wing, possibly an explanation of this occurrence may be found by assuming that through this aperture, giving direct communication between the pressure side (lower surface of the wing) and the suction side (upper surface), the positive air pressure is brought to bear on the inner side of the fabric in the upper wing surface, thus causing a far greater strain on the stitches than is normal. Therefore not only was a better thread used for stitching the fabric to the ribs but two small holes were made in the upper surface near the trailing edge.

DETAILS.

The steering gear is good, though its construction does not come up to the English standard. A commendable feature of the Fokkers is the double aileron control, which should be standard on war machines.

The bearings of the control stick developed play too quickly, therefore these are being changed in the Dutch Air Service, and ball bearings are mounted instead of the original bronze bushes.

The different cockpit fittings (gas and ignition handles, petrol cocks, safety belts, cockpit upholstering, etc.) were more or less of a perfunctory nature, showing that these machines were equipped according to war-time ideas of their time of service. They are quite sufficient for a machine which in the course of a couple of months is either wrecked or superseded by a new type, but for machines intended to serve during a lengthy period in peace time more attention should be given to these details.

The motor cowling, built up of different loose sheets, fixed by winged nuts, is very practical, as stated before, but the interchangeability of these sheets leaves much to be desired. Practically no two cowling sheets and machines have the holes and bolts in the same place. A lot of trouble would have been saved if at the outset more attention had been given to interchangeability.

This remark applies also to petrol tanks, radiators, empennage, interplane struts, etc.

Radiators gave some trouble (leaks) owing to their rigid mounting. When mounted on felt washers very little trouble was experienced with the honeycomb type.

CONCLUSION.

The Fokker C–I, as well as the Fokker D–VII, has given great satisfaction in service.

The different difficulties which were encountered are, all of them, of a minor character and can be remedied with small trouble.

The general impression left by 11,000 flying hours' service is an excellent one.

ENGLAND.

RÉSUMÉ OF BRITISH RESEARCH DEVELOPMENT IN SERVICE AIRCRAFT.

WIND TUNNELS.

One of the striking things noticed in England was the existence of wind tunnels at practically all the important aeronautical manufacturing establishments. As these vary in scale, dimensions, and charcteristics, it is very hard to correlate the data in concrete cases for comparison. The principal purpose of these was to get relative data which would be close enough to show the immediate relative advantages even though they could not be applied by correction factors to accurate full-scale machines.

The tests conducted are further valuable to ascertain conditions of fore-and-aft stability and for getting measurements of relative resistances.

AERODYNAMICS.

A large amount of full-scale work has been done for measuring the full-flight variations of different airfoil sections. The English have used a thrust meter to advanatage in helping to evolve characteristic full-flight data.

Other research work is being carried on at present in the form of increasing controllability of airplanes at low speeds, endeavoring to attain efficient control disposition. Further investigations will be carried out in the near future on the comparison of water-cooled and air-cooled engines from the standpoint of consumption of power for cooling. Cooling with radiators will be compared to direct air-cooled cylinders. The direct merit factor as regards water-cooled versus air-cooled power-plant installation in a hypothetical airplane will be tested to determine the choice from a viewpoint of the total resistance of the machine in each case.

The British research department is investigating the problems of control at low speeds, and the solution of this problem may, in their opinion, give more advantage than the development of wings of high lift.

STABILITY DATA.

A considerable amount of work on stability derivatives for prediction of stability characteristics of aircraft is being done. They desire more practical assumptions for supplying data to airplane designers to aid them to anticpate in advance the stability properties of aircraft.

AIRFOILS.

It has been noteworthy that, with the Handley Page slotted wings, DH-9's have been more efficient and have had greater climbing ability than when fitted with standard wings. The launching run with the Handley Page wing was one-half that of the run when fitted with the ordinary wing.

The model tests on the Alula wing have not shown any exceptional advantage, but the possibilities of large correction factor advantage on full-scale models were being explored. The designer made radical statements as to the fallacy of correction factors that are now being applied from wind tunnel model experiments to full-scale airplanes.

STATIC TESTS.

The assumptions for carrying out the static tests of aircraft and for methods of calculating stress for aircraft structures have been standardized by the Air Ministry and assumptions are followed as in Pippard and Pritchard's Air Ministry Handbook of Strength Calculations.

Of course it is known that the more accurately the loading in flight is done, the lighter the airplane structure can be made and, as heretofore mentioned, full-flight pressure-zone tests have been conducted and are being employed as a guide to the attainment of a more accurate knowledge of the distribution of load and of stress. It has been found to differ quite appreciably from the model pressure tests in smaller scale. Finally, the more exact knowledge of the full-size pressure distribution will certainly give more exact nature of loading and a lighter structure, and give the industry more simplified assumptions which, though not strictly accurate, should in the main be accurate enough for practical use. Furthermore, the British aeronautical structural engineers are engaged in the simplification of accurate calculations for redundant aircraft structural members.

FLIGHT TESTS.

In most of the full-scale flight-test experimental work at the Farnsborough station the investigators were people charged with the solution of flight-test problems, actually carrying out their own flying problems themselves. This is significant when one considers the advantage to the investigator or scientist of getting this first-hand information from full-flight testing himself. Tests are also being conducted in full flight for determining the regions of varying pressure along the wings, along the fuselage, and in the region of the landing gear and tail surfaces.

AILERONS.

Different adaptations of aileron counterbalancing features have been evolved by different manufacturers to correct for and minimize the amount of fatiguing exertion required of the pilot to maneuver the ailerons throughout the operating ranges for lateral control. In one instance, the *DH-34* and *DH-29*, the aileron demultiplying control system of leverage and angular range has been so designed that the high side aileron is moved through a

greater angular range than the low side aileron. This, in combination with the counterbalanced aileron leading edge, offset from the aileron spar proper, allows for lateral control with much less exertion than would normally be required.

The latest Handley Page has the ailerons counterbalanced all along the leading edge in such a way that after obtaining the maximum positive and negative range of aileron control position the leading edge of the aileron counterbalanced portion does not extend beyond the upper or lower limits of the spar section. They claim this is a decided advantage and makes lateral control easier.

ADJUSTABLE TAIL SURFACES.

In large airplanes of the multimotored type different schemes have been adopted for varying the tail settings on the horizontal and vertical surfaces to correct for the longitudinal fore-and-aft trim, due to the variation of load about the normal center of gravity and also for correction of directional control which is ordinarily upset by one motor cutting out, thus making it difficult for the pilot to maintain direction with the flexible rudder control.

In the Bolton & Paul, and most of the other British multimotored types or single-motored types requiring fore-and-aft adjustment, the stabilizer is variable in incidence at the control of the pilot from the cockpit. However, in the Vickers Vimy type, in correcting for one motor cutting out, the rudder bar in the cockpit is offset by a telescopic hand-loading spring arrangement fastening between the rudder bar and floor structure of the airplane so as to neutralize the effort required of the pilot to correct for the uneven thrust couple involved. In the Bolton & Paul type a double-hinged rudder and fin combined is utilized so that the forward hinged portion of the fin part is set in an angular position by means of a handwheel control in the cockpit. The rudder proper is hinged to the aft end of this adjustable fin and is coupled directly to the rudder-bar controls in the cockpit.

METAL CONSTRUCTION.

One of the many problems in connection with alloy steels and nonferrous alloy in England has been the procuring of the best metals for commercial use which have been evolved in laboratory tests.

ALL-METAL PLANES.

The English have been very slow to follow up the trend of metal aircraft development in France and Germany. The Vickers Co., the progenitors and patentees of duralumin, did not have any duralumin experimental aircraft work under way in their factory at Wybridge that could be seen. The only application of metal to aircraft that was noticed there was in the use of high-alloy steel tubing with external steel fittings. The Short Bros. Co. are the only people to have used duralumin to any extent on an airplane in England. Detailed description of their *Silver Streak* will be found under the heading, "Short Bros. all-metal planes." This is a very creditable interpretation of a duralumin fuselage.

The Bolton & Paul Co. are using high-alloy sheet shapes and the Siddeley Co. is using in their all-metal aircraft high-alloy steel tubing and alloy sheet spars and ribs throughout. This is a very expensive wing construction and is very difficult to repair. The fuselage steel tubing idea of structure is fairly well interpreted and makes for a sound structure.

Mr. J. D. North, chief engineer of the Bolton & Paul Co., says duralumin is a washout. Some information is current in English aeronautical circles that duralumin deteriorates with age and loses some of its physical characteristics. However, this should be investigated and traced for authenticity.

Welding has been absolutely discouraged in aircraft construction in England, but this action should not carry much weight, inasmuch as the English have not had any practical experience in the use of welded construction. Their assumptions and conclusions have been entirely theoretical and are prejudiced.

RADIATORS.

A large number of radiators installed on British machines are still of the nose type. However, in the De Haviland, Fairey, Bolton & Paul, and several others, radiator installations have been placed in the partial free air position such as the engine underslung tunnel type with honeycomb core.

The English have been employing very low caliber ratios for their radiator cores and have not attained the ultimate efficiency of a straight core tunnel radiator that would ordinarily be the case if higher caliber ratios of 35 had been employed in these regions of high velocity.

OLEO LANDING GEARS.

One of the latest and most widely applied developments pertaining to airplane landing gears has been that of the Oleo shock-absorbing type and its use by the Bolton & Paul Co., Bristol Airplane Co., De Haviland Airplane Co., Armstrong-Siddeley Airplane Co., Handley Page Co., Vickers Co., Martinsyde Co., etc. The idea, according to the different designers questioned, was to eliminate as far as possible the secondary rebound in airplanes which is prevalent with the rubber shock-absorbing type landing gears. By applying the Oleo dashpot principle in combination with rubber or spring shock absorbers, or in Oleo dashpot fashion alone, the shock is damped more readily. In America there has been no evidence of an Oleo type landing gear. This ought to be one of our next lines of endeavor in experimentation on an airplane such as the Martin, or other serious service types.

PALMER TIRES.

The Palmer Co. has recently developed a new tire for large airplanes requiring large wheels and large diameter tires with a flattened tire casing tread so as to allow a higher resistance of these wheels in going over soft ground. These should be tried out on our Martins.

PURSUIT PLANES.

The 300-horsepower Hispano motor is not being used in England at this time on any of their later types. Their pursuit plane program, now and for the immediate future, will be with machines equipped with the Siddeley Jaguar engines or the Bristol Jupiter engines. Detailed characteristics of the Siddeley Siskin are included in an Admiralty performance report embodied in this report.

OBSERVATION PLANES.

The Bristols equipped with Rolls-Royce engines are still being used by the English for their two-seater work.

NIGHT BOMBARDMENT PLANES.

The Handley Page and Vickers Vimy bombers are on their program for night bombardment purposes. The day bombardment types are still mainly the De Haviland class of aircraft.

TROOP CARRIERS.

An interesting type that the English have been experimenting with and building in small quantities are the Vickers troop carriers. These machines are standard, multimotored, bombardment types, redesigned to carry troops lightly equipped. A similar type is being constructed by the Siddeley Co., having two Napier Lion engines. These ships have been principally evolved for colonial use where troop transportation is a problem. If this type is warranted in our service program, we could follow suit by adapting one of our large bombardment types, with provision made in the fuselage for locating the troop load and their light field equipment, such as rifles, ammunition, food, etc. This type is quite analogous to a large commercial multimotored type. If it were decided to develop this type, it might be advisable to do so as a commercial ship and to study adaptability for this use.

TORPEDO PLANES.

The Blackburn Co. and the Handley Page Co. have been awarded experimental contracts on torpedo-carrying machines. The details of the latest Handley Page torpedo-carrying type have not been divulged, although a Blackburn torpedo-carrying type has been purchased by the United States Navy and is now in this country. Specifications of the Air Ministry torpedo type have been procured and are included in this report.

As a result of the extensive torpedo-carrying airplane experiments that have been carried on by the British it would seem advisable to carry on experiments with the torpedo-carrying type in our service and to evolve a type specification for it, following very closely the specifications advanced by the British.

AMBULANCE PLANES.

They have also evolved in practice an interpretive ambulance type airplane by changing over the standard Vickers Vimy passenger-carrying machine. Specifications for the Air Ministry type airplanes have been included in this report.

Inasmuch as a satisfactory ambulance type airplane has not been built in this country with reference to number of patients carried, equipment, desirable landing speeds, etc., it would seem quite necessary, inasmuch as there is practical use for this type of airplane, that we give it serious consideration in the future. The preliminary consideration should be layout and disposal of the load, with marked facilities for landing in very mediocre fields.

AMPHIBIANS.

English amphibian development has been successful in so far as the application of removable landing gears is concerned. The poor performance, small military load carried, difficulty of handling, poor field of fire, and the low ceiling obtainable, all combine to make them a very undesirable type to develop from a military standpoint. The characteristics of their latest amphibians are approximately as follows:

The Super-Marine, Fairey, Parnell, and Vickers types:
- Ceiling, average: About 16,000 feet.
- High speed: About 110 miles per hour.

The Super-Marine amphibian is the flying boat type with a Napier Lion engine mounted in overhead fashion. There is a gunner to the rear of the wings in the hull, and one gun is located forward.

The Vickers type is analogous to the Super-Marine type so far as disposition of load and general arrangement is concerned. The blind angles caused by the tail unit and by the main wing structure are considerable. The logginess of the types is very pronounced. They would afford a very easy mark for land pursuit planes in case of war.

The Parnell and Fairey are of the fuselage twin-float biplane seaplane type. These machines offer a better range of gunfire for the rear gunner due to underslung rudder, but, as a whole, they have the same disadvantages of logginess, poor visibility, and very mediocre performance.

LARGE FLYING BOATS.

The British seem to be giving considerable importance to the development of large flying boats by allowing contracts for large multimotored flying boats of the Fairey N-4 type.

Fairey N-4 type flying boat.

The hull of the flying boat is approximately 66 feet in length, including rudders. The lines of the hull are quite similar to the hull of the F-5 flying boat. The hull was built to Air Ministry design and has the following characteristics:

- Area of wings: 2,900 square feet.
- Area of tail: 350 square feet.
- Rudders: 50 square feet.
- Fins: 50 square feet.
- Elevators: 50 square feet.
- Ailerons: 83 square feet.
- Span: 139 feet.
- Height: 29 feet 6 inches.
- Length over all: 66 feet.
- Chord: 12 feet 6 inches.
- High speed: 105 miles per hour.
- Power plant: 4 Rolls-Royce Condor 600-horsepower engines mounted in twin tandem eggs between the wings.
- Float displacement with full load: 32,000 pounds.

The hull is not divided into water-tight compartments. The runway extends along the whole interior of the hull. Gasoline tanks are secured in cradles on each side of this runway. It is intended to provide sleeping accommodations for the crew. In the tail two large portholes, one on each side, are provided with water-tight doors so that four machine guns may be mounted there.

Fan-driven Servo motors are installed in the tail for aiding the pilot in controlling the ship.

This machine is situated at the Isle of Grain Naval Air Station and has been developed principally because of the belief in some naval circles that seaworthy flying boats of great range and of large size which can follow the fleet and operate with it wherever it goes, for fleet reconnaissance work, are more practical than other types. They claim that landing on capital ships is impractical and that capital ships in battle formation would not alter their course in order to enable craft to return to them.

Vickers Valentia type, and the large Fairey Atlanta powered with four Rolls-Royce 600-horsepower Condor engines.

Seaworthy tests are being made on these large-type flying boats which weigh as much as 15 tons. Inasmuch as the launching and landing of them is a large task, it is necessary that they be capable of being moored out on the open sea for a considerable length of time.

DECK FLYING.

A considerable number of experiments are being made in flying off and landing on the decks of airplane carriers, with a view to ascertaining and developing shipboard aircraft for open-sea warfare. It is hoped that the development of their amphibians may be the solution to this problem.

Although aircraft equipped with wheels may take off from a capital ship with ease, it was thought that capital ships should carry scouts equipped with skids instead of wheels, taking off from greased troughs and then landing on aircraft carriers. This was Commander Busteed's opinion. It is accomplished by having an attachment fastened on the landing gear for engaging with wires strung forward or aft on the deck of the carrier.

The English ship planes for landing on aircraft carriers are all equipped with a harpoon spring-locking hood device. This hook has a pitch between the hooks of apparently 8 inches to allow for hooking over cables strung fore and aft along the decks of the aircraft carriers. The hook engages with these cables and keeps the plane from swerving off the deck. It is a very simple adaptation, mechanically sound and practical in its application, although it means an increase in head resistance. These harpoon hooks are fastened on the landing-gear axles.

TRAINING PLANES.

The Avro training machine is still the standard English training type, and one of their latest Avros that was formerly powered with rotary engine has been changed over with the Hispano 160-horsepower motor.

The British have a large number of Nieuport Nighthawks that were designed for the ABC nine-cylinder air-cooled engines. This machine is now undergoing tests at Martlesham with the Siddeley Jaguar 350-horsepower, radial, air-cooled engine, in order to adapt this type to their pursuit program. The Siddeley Siskin, however, is a more advanced type, having better maneuverability and climb and equal in speed to the Nieuport Nighthawk.

HELICOPTERS.

Very little enthusiasm is being shown in Great Britain over the possible advent of helicopters. However, the British Air Ministry appreciates the possible advantage to this type for ultimate adaptation, inasmuch as they are contemplating to allow $200,000 as a prize for the development of a helicopter to fulfill certain conditions prescribed by their experts. There is a decided antihelicopter sentiment throughout the entire heavier-than-air industry in England.

Mr. Brennan has designed and built a helicopter at Farnsborough which is being tested in secret. This helicopter, according to claims, has risen from the ground with its own power with 250 pounds weight. The nature of experiments with this type has not been divulged, but it is understood that further flight tests will be made very soon.

ENGINES.

The British are striving to produce a suitable airplane engine that will be absolutely reliable and have a long life between overhauls. These fundamentals they consider are most important for reliability in the operation of aircraft. They are also endeavoring to reduce the fuel consumption in the different aircraft engines. Experiments are being conducted at Farnsborough to determine the relative advantage of fuel injection over the conventional carburetor systems on our present-day internal combustion types. They are also trying to use shale oil in developing Diesel cycle units. Diesel type single-cylinder units are being used in the dynamometer laboratory at Farnsborough. Experiments are also being conducted with alcoholic fuels. Mr. Taylor, the dynamometer engine expert, stated that the advantages of direct injection would be a high-flash point fuel with reduced fire risks, higher compression and efficiency, more economical fuel consumption, a fuel supply independent of pressure heads, reliability not interfered with by dirt in fuel, and the entire elimination of magneto type of ignition.

In certain tests a single air-cooled cylinder that they have developed has given as much as 200 horsepower. They hope that a 1,000-horsepower air-cooled engine will be possible. Such an engine would be desirable with a gear reduction of about 2 to 1 for the propeller.

The results of development tests of the Bristol Jupiter and Siddeley Jaguar engines have convinced the British motor experts of the practicability of design, construction, and operation of light air-cooled engines.

Important consideration should be attached to the pursuit development in Great Britain, particularly as to the type involved, that is, the maneuverable and climbing type with radial air-cooled engines. The Siddeley and Bristol radial, air-cooled engines have passed the Admiralty tests. This type should be studied from a standpoint of adaptation to airplanes for which it would be desirable.

Inasmuch as we have not developed radial air-cooled engines beyond 200 horsepower in this country, it is advisable that we immediately expedite the development of a 400-horsepower type with the limitation of 2 pounds per horsepower in weight, or we should encourage the American manufacturers to procure rights for the Siddeley Jaguar engine and the Bristol Jupiter type. This should be done after exhaustive tests have been made in this country on the experimental Jaguar and Jupiter that we have purchased or will purchase in the near future.

The 450-horsepower Napier Lion engine is being most extensively used in English military and commercial

types. This engine has been fully service tested and proven.

MOTOR MOUNTINGS.

The motor mountings on the more advanced types of airplanes in England are of the cantilever pyramid type. They are built attachable so as to allow for the ultimate and immediate replacement of engines while in commercial or military service.

The fire walls, according to the latest English ideas, should be of the metal-faced, asbestos-core-lined type, and holes that would ordinarily be pierced through the fire walls for allowing the passage of controls, wires, etc., should be minimized to the greatest extent. Where rods or wires absolutely have to be put through the fire wall, it will be necessary to use the gland connection so as to absolutely do away with any chance of flame or gasoline seeping through.

ENGINE MUFFLERS.

A great number of contrivances have been rigged up in England for the muffling of engines. Bolton & Paul Co. has gotten up a partitioned aluminum casting air-cooled exhaust manifold, on the outlet extremity of which is fastened a light steel gauge exhaust manifold extension with a closed end. This pipe is about 3 inches in diameter and about 6 feet long. It is perforated throughout all its length on the outer half, away from the fuselage, with rectangular slots of about 1 inch by one-eighth inch. This apparently helps to dampen out the noises due to the explosion enough to permit communication by word of mouth between pilot and observer. The aluminum exhaust manifold is partitioned with telescopic joints extending between each pair of cylinders in the bank so as to do away with the possibility of cracking and reduce the strains due to cooling. It is cooled by projecting aluminum fins so as to obviate the danger of fire which so often occurs from hot manifolds.

SUPERCHARGERS.

A DH–9 has been fitted with a supercharger which is very similar to our General Electric type. Although results of their tests have not been divulged, it is significant that they claim a practical solution for their type. They also claim to have realized sea level horsepower at very high altitudes. The necessity for variable pitch air screws is just beginning to receive consideration. They have experimental projects for further development.

STARTERS.

Different principles for automatic engine starters have been tried in England. One proposed by Major Norman, formerly of the R. A. F., is constructed by the Bristol Airplane Co. This starter consists of a single-cylinder, light-powered, air-cooled engine and small compressor which forces a pressure mixture into all the respective engine cylinders in time, thus throwing the engine over. This self-starting arrangement takes its gasoline from the main service tank and is not prohibitive in weight, weighing approximately about 45 pounds installed.

The installation that we witnessed was in a DH–4. The small motor was installed directly back of the observer's cockpit and the observer could turn around in his cockpit and turn it over by hand. The starting can be controlled either by the pilot or the observer from the instrument board. Practically all of the English service and commercial airplanes have been equipped with propeller front flange connecting clutch for adaptation to field starting of the airplane from an auto truck portable engine-driven starter.

There are two well-known types of field starters in England; one, the Aircraft Disposals Board Ford motor car starter. It is very practical, very effective, and very well liked at all the airdromes that we visited in England. Another well-known auto starter is the Crossley Motors model. This is a much larger auto unit and has a vertical extension starting tower capable of being regulated in height for starting motors in huge airplanes with the motors high off the ground, such as in the Handley-Page, Vickers Vimy, DH–34, and similar types. Of course, the main disadvantage is the fact that these are external means of starting and really do not solve the integral self-starter installation on aircraft, which has been attempted in the Bristol type.

Personally, it is believed that for home airdromes the idea of a field auto truck starter is sound and deserves attention.

FUEL SYSTEMS.

The trend in commercial aircraft has been to locate separate fuel tanks out and away from the fuselage, either underneath or on top of the upper wing in gravity feed fashion or on top or underneath the lower wing and fed to motor with a fan-driven fuel pump.

With the latest type military aircraft, pressure systems are being avoided and fan-driven Vickers gasoline centrifugal pumps are being installed on most of the machines in conjunction with the gravity auxiliary system.

On multimotored airplanes it is desired as far as possible to have independent fuel supply system for each power plant, working independently or in unison at the control of the pilot. The separate gravity tanks are also at the control of the pilot. In these large multimotored airplanes, auxiliary direct feed hand pumps of large caliber are installed within easy access of the pilot so as to permit filling of the gravity tanks from the main service tanks in case the fan-driven gasoline pump system should fail

FIRE HAZARDS.

A great deal of attention is also being paid to the neutralization and elimination of all existing fire hazards. Toward this end the British have organized fire-prevention committees made up of the most representative engineers to investigate and make recommendations of practical measures to reduce the danger on standard power plant installations and fuel systems. It is desired to evolve a machine as nearly as possible resistant to dangers of fire, whether in the air, on crashing, or running on the ground.

PETRO FLEX.

One practical result so far that helps is a hose connection. Mr. Blaisdell has developed a gas hose called petro flex which seems to stand all tests that is has been put to. The fact that rubber joints in gasoline lines have been a constant hazard in existing fuel systems has lead the Air Ministry to evolve an all-metal coupling, thus making the complete circuit entirely metal.

The fire prevention committee has recommended placing tanks away and out from the fuselage, fastening them on the wings, and thus obviating the danger of leaking gas from the damaged tanks getting into the region of the hot exhaust.

Experiments are also being conducted with Pyrene fire extinguishing systems similar to the Burke system developed at McCook Field.

PROPELLERS.

All possible impetus is being given toward the development of all-metal air-screws because of demands for their adaptation on service colonial type machines in the East, in Mesopotamia, and in Egypt. The employment of wooden propellers of the conventional type has not been satisfactory in these countries. The British are not aware of the advantages of the American Bakelite propeller for this work.

BOMB INSTALLATION.

The trend of bomb installations is to put them under the fuselage. This obviates the large head resistance that would be inherent with exterior wing installation such as was used in the war.

MACHINE-GUN INSTALLATION.

The fixed machine-gun installations are practically all of the exposed type, being placed on a level with the pilot's shoulders. In cases where ammunition required for two fixed machine guns is in the neighborhood of 2,000 rounds, machine guns are staggered in a fore-and-aft sense and the ammunition boxes paced one in front of the other to permit minimum fuselage displacement.

On most of the single-seater machines spade grips are being employed with motor cut-out switches for use in connection with rotary engines. Two gun triggers are situated in the heart of the grip so as to ease the control and manipulation of the gunfire when in combat by the use of the thumbs instead of the hand. This permits retaining control of the ship with the least effort and allows the pilot to get much better sighting without recurrent handicaps of being obliged to finger around for the trigger control.

WIRELESS GENERATORS.

Wireless generator installations are nearly always effected on military type aircraft in the lower wing, either in the leading edge of wing, on the fuselage side, or fixed on a bracket fastened to the front spar. There was not a single installation on the landing-gear struts in England.

INSTRUMENTS.

The instrument section at Biggin Hill has designed and constructed a sound beam airdrome indicator for use at airdromes in helping pilots to find their landing place in case it is impossible to see the ground because of fog or clouds. This apparatus consists of a big, parabolic, concrete bowl whose concave section is about 15 feet in diameter. This is suspended on a rack about 25 feet above the ground. This bowl can be operated manually at will to face in any direction within a hemisphere. Immediately to one side of this installation is a manually-operated air compressor with storage tank with hand-operated release. This blows a siren whistle which is directed into the bowl. The sound entering this bowl is echoed in a straight line.

The pilot of the incoming airplane, desiring to locate this airdrome in a fog, endeavors to travel along this beam of sound where the intensity is the greatest. Inasmuch as this sound beam is intensified in one direction only, at the control of the operator on the ground, and if the intensity of this sound beam becomes less audible to the pilot of the airplane he immediately tries to get into the zone of high intensification of sound and thereby tries to effect his course in this manner. This is purely experimental and it is not known whether or not it will be entirely practical. However, these experiments should be closely observed and may introduce some possibilities of solution of this difficult problem.

Considerable work is being done in developing navigation instruments. The necessity for this has been manifested in a large measure by the experience gained in the continental commercial air services.

The gyro installations to run the turn indicator are operated by energy from the propeller slipstream on the latest type in England.

LIGHTHOUSES.

The English have developed lighthouses at their Croydon airdrome which have a concrete conical base terminating in a centralized pillar, at the top of which are four electric lights with overhead reflectors which reflect the light against the projected face of the conical base. This is a very easy landmark light to be observed at night, without any hazardous glare.

AERIAL AIRCRAFT CARRIERS.

Experiments have been carried out by the English at the Isle of Grain with a view to determining the practicability of hooking on a cable suspended on each side of a battleship or from an airship. These tests were made by the Royal Air Force pilots with a Sopwith Snipe. A three-eighths-inch cable was suspended in this experiment between four poles (two at either end) situated 200 feet apart. The two poles at either extremity were far enough apart so that a machine could very readily pass between them and engage the main three-eighths-inch cable on flying directly underneath. This is fastened to the two V wires, which in turn are fastened to the two poles at either end of the course. On the main cable a wire loop, approximately 18 inches in diameter, was loosely fastened. About 18 inches above the top plane of the airplane a hook about 10 or 12 inches in diameter was fastened, clearing the periphery of the propeller zone by about 18 inches. This main cable was situated about 25 feet above the ground.

From the success achieved in this experiment it is obvious that the possibility of hooking on the bottom of a dirigible is absolutely plausible. The main precaution to be taken is in keeping the plane upper wing hook at a reasonable distance above the propeller so as not to hit the cable with the propeller. It would be highly advisable to have some pilots volunteer to make experiments in this country with one of our analogous types.

THE ALULA WING.

The Alula wing, designed by Alex Holle, has been developed by the Commercial Wing Syndicate of London, England. This wing has a varying section tapered out

to a point at the extremities of the wing tips. The air foil is twisted from the root out toward the tip in order to decrease the angle of incidence. According to the designer, it will be possible to entirely obviate the end losses prevalent in all present types of wings. The Alula wing is not a specific air foil but a theory which the designer states can not be proven in the wind tunnel but which will give a very high lift wing for weight carriers if tried on a full-scale model.

The Royal Aircraft Establishment conducted wind tunnel tests and then had a wing built and fitted to a Martinsyde F-4 fuselage. They claim that there was no marked advantage or improvement over other types. This was also the conclusion of the French and Italian technical sections and of Doctor Junkers.

There is no actual physical evidence in Europe to prove the superiority of the Alula wing.

AIR MINISTRY TORPEDO MACHINE SPECIFICATIONS.

D. of R. Type 8.

SPECIFICATION OF PARTICULAR REQUIREMENTS TO ACCOMPANY THE GENERAL SPECIFICATION FOR EXPERIMENTAL CONTRACTS.

This specification is to be regarded for contract purposes as being part of the general specification herewith, and as subject to the same conditions.

1. *General requirements.*—The aircraft is to fulfill the duties of "Torpedo-carrying aeroplane for fleet use."

The aircraft is to be designed to accommodate the full equipment specified in paragraph 6.

The aircraft should have a good degree of positive stability in all directions, and trimming gear should be fitted so that the tail plane can be set to insure that the aircraft will fly horizontally at any speed within the flying range without requiring attention from the pilot.

The aircraft must be controllable at all flying speeds and good controllability near stalling speed is essential.

Special attention should be paid to maneuverability.

The aircraft must answer all controls quickly and must not be tiring to fly.

The crew and armament are to be arranged as specified in paragraph 7 of this specification.

The arrangements for alighting and taking off are to satisfy the special requirements laid down in paragraph 8.

The aircraft is to be constructed in conformity with the published requirements of the director of research.

2. *Power unit.*—The engine is to be a Napier Lion (of which the following particulars may be assumed). The engines will be substantially as outlined on the attached installation print.

(*a*) Weight, dry: 840 pounds.

(*b*) Normal horsepower, 2,000 revolutions per minute: 450.

(*c*) Maximum horsepower at 2,100 revolutions per minute: 468.

The propellers are to be so designed that the revolutions per minute stated in (*c*) can not be exceeded under normal circumstances. The engines are to be installed in conformity with the published requirements of the director of research.

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A plate is to be affixed in clear view of the pilot, stating that engine is not to be run at the maximum revolutions per minute stated in (*c*) for a period exceeding five minutes.

Tankage, including service gravity tank, is to be provided for—

Fuel, 80 gallons.
Oil, 6 gallons.
Water, 2 gallons.

Gravity tank with a capacity of not less than 16 gallons is to be provided.

Gasoline feed may be either:

(*a*) By Vickers or other approved gasoline pump from the main tanks direct to the carburetors with a by-pass to a gravity tank so situated that in normal flying position there is a minimum effective gasoline head of 20 inches above the gasoline inlets to the carburetors.

(*b*) By Vickers or other approved gasoline pump from the main tanks to a gravity tank, and thence to the carburetors. In this case the gravity tank must be so situated that when the machine is flying at its maximum climbing angle there is a minimum effective gasoline head of at least 20 inches above the gasoline inlets of the carburetors.

The area of the main gasoline pipes should be such that the flow of gasoline sufficient for maintaining full power is exceeded by 100 per cent when the carburetor unions are uncoupled and the supply is in the condition of minimum head.

The cooling and gasoline systems are to be in accordance with the published requirements of the director of research.

Provision is to be made for rapidly emptying the main petrol tanks.

3. *Load to be carried.*—The load to be carried on the acceptance flight is to be as follows:

Crew (1): 180 pounds.
Torpedo Mk. VIII: 1,500 pounds.
Torpedo dropping and adjusting gear: 75 pounds.
Wireless telephony set: 70 pounds.
Torpedo heating gear: 40 pounds.
Aldis lamp: 5 pounds.
Instruments: 40 pounds.
Accessories: 200 pounds.
Fuel, 80 gallons: 584 pounds.
Oil, 6 gallons: 60 pounds.
Water, 2 gallons: 20 pounds.

4. *Contract performance.*—The performance with full load as specified in paragraph 3 and with engine revolutions not exceeding those stated in paragraph 2 (*b*) is to be:

Speed at 2,000 feet, not less than 95 knots.

Rate of climb at sea level not less than 750 feet per minute.

Service ceiling, not less than 15,000 feet.

Length of run required to get off not more than 150 feet in a relative wind of 20 knots, or to the satisfaction of the director of research.

5. *Structural strength.*—The strength of the main structure is not to be less than the following standards when carrying a full contract load as specified in paragraph 3.

Load factor on front truss with center of pressure forward, not less than 6.

Load factor on rear truss with center of pressure back, not less than 4½.

The failing strength of the fuselage is to be determined by the method described in the Handbook of Strength

Calculations HB. 806. The factor required in the limiting nose-dive case is not less than 1.5.

The load factor mentioned above will be determined by the method in the Handbook of Strength Calculations HB. 806.

6. *Equipment.*—The following equipment is to be provided for, and the contractor will be required to supply and fit all parts necessary for its installation.

(*a*) Mark VIII torpedo:
 Length, 16 feet 7.4 inches.
 Diameter, 18 inches.
 Center of gravity, 112.9 inches from aft end.
 Provision to be made for carrying alternatively either the Mark VIII or Mark IX torpedo.

(*b*) Torpedo dropping and torpedo depth adjusting gear.

(*c*) Torpedo heating gear.

(*d*) Aldis lamp.

(*e*) Bomb sight.

(*f*) Bomb gear for two smoke-producing float bombs or two 520-pound high-explosive bombs. Weight of smoke bomb, provisionally 300 pounds.

(*g*) Wireless apparatus as specified.

(*h*) Navigation and recognition lighting equipment.

The following instruments of approved pattern are to be fitted in pilot's cockpit.

Air-speed indicator.
Altimeter.
Watch.
Revolution indicator.
Oil-pressure gauge.
Fuel-flow indicator.
Cross level.
Fuel-level indicator.
Radiator thermometer.
Compass.
Torpedo-depth indicator.
Pyrene fire extinguisher.

7. *Disposition of crew and armament.*—The pilot must have a good view downward and forward for the purposes of deck landing. He must also have a good view forward from the horizon downward for the purposes of torpedo sighting. Torpedo-dropping gears and torpedo depth-adjusting gears must be led to the pilot's cockpit.

The alternative bomb load is to be carried under the wings.

8. *Arrangements for alighting and getting off.*—The aircraft is to be designed to take off from the deck of an airplane-carrying ship, with full specified contract load, in the distance specified in paragraph 4 of this specification.

It must be designed to land on the aft deck of such a ship steaming into the wind and a relative wind speed of 20 knots can be assumed.

Provision must be made for the attachment of suitable arresting gear hooks and propeller guard if necessary, and for suitable restraining slings with quick release.

The aircraft must be capable of landing on the water (without torpedo) without turning over and must be fitted with suitable flotation gear, so designed that the machine will remain afloat for six hours in calm weather.

Particulars of the arresting gears as fitted to H. M. ships and of all experiments on flotation gear will be supplied on application to the director of research.

9. *Miscellaneous.*—The aircraft is to be fitted with hoisting slings suitably attached. The slinging gear is to be designed to take three times the "all up" weight of the aircraft.

A pennant is to be run from the hook of the slings to the sternpost, being run along the top longeron, to which it is to be attached by breaking strips. Suitable holding-down rings are to be provided under the bottom planes. The wings are to be designed to fold easily, and with wings folded the maximum over-all dimensions of the aircraft are not to exceed:

Width, 17 feet 6 inches.
Length, 37 feet.
Height, 13 feet.

With wings spread the following dimensions must not be exceeded:

Span, 46 feet.
Length, 37 feet.
Height, 13 feet.
Tail span, 15 feet.

The distance from the leading edge of the forward main plane to tip of rearmost fitting on the aircraft must not exceed 29 feet and 6 inches.

The maximum weight per wheel in pounds should not exceed 12 times the product of the wheel and tire diameters in inches with the aircraft carrying full contract load.

The aircraft is to be designed to resist as far as practicable the corrosive effects of sea water.

10. *Contractor's trials.*—The contractor may be required to demonstrate in the air and with his own pilot that the aircraft is safe to be flown by an officer of the Royal Air force.

11. *Delivery.*—Delivery will be to the officer commanding, Royal Air Station, Martlesham Heath, unless otherwise directed. The first aircraft to be delivered within 12 months of the receipt of instructions to proceed.

12. *Acceptance.*—The aircraft will be accepted on delivery to the above station, but the contractor will be required to make good at his own expense any defects in construction or design which may be revealed while the aircraft is undergoing official trials at the above or any other service station.

13. *Spare parts.*—The following spare parts are to be supplied for each three experimental aircraft:

One complete set of streamline wires.
Three tail skids complete with all fittings.
One complete undercarriage.
One complete tail unit.
Three propellers.

Delivery of spare parts to be made concurrently with the first aircraft delivered, and payment for the aircraft will not be deemed due until this requirement is fulfilled.

THE ROLLS-ROYCE COMPANY.

The Rolls-Royce Co. has practically perfected their Condor 650-horsepower, 12-cylinder, water-cooled, V engine for service use. This engine weighs approximately 2 pounds per horsepower, dry, and its characteristics are as follows.

ROLLS-ROYCE CONDOR AERO ENGINE.

Series 1 A.

General.—The Rolls-Royce Condor aero engine is of the 12-cylinder, water-cooled, V type, fitted with the epicyclic reduction gear, magneto ignition, and complete with propeller hub and engine-supporting brackets suitable for tubular bearers.

The characteristics of the engine are as follows:

Number of cylinders: 12.
Bore: 5½ inches.
Stroke: 7½ inches.
Normal B. H. P.: 650.
Normal speed (crankshaft): 1,900 revolutions per minute.
Maximum speed (crankshaft): 2,000 revolutions per minute.
Normal speed (propeller) with 0.5537 reduction gear: 1,055 revolutions per minute.
Fuel consumption at normal power and speed: 45 gallons per hour.
Oil consumption: 1.9 gallons per hour.
Weight of engine, including propeller hub, carburetors, magnetos, engine feet, electrical power starter, etc., but excluding reduction gear, exhaust boxes, radiator, oil, fuel, water and starter battery: 1,284 pounds.
Weight of engine, as above, but including reduction gear: 1,552 pounds.
Weight of engine, complete with all the above but without radiator, water, oil, fuel, and starter batteries: 1,606 pounds.

Cylinders.—The cylinders are separately mounted on the crank case in two rows of six, at an angle of 60° with each other. They are of built-up all-steel construction, being machined from 0.6 per cent carbon steel forgings with the heads integral with the cylinder barrels. The water jackets are die-pressed sheet steel, acetylene welded at the joints. The valve seatings are machined in the cylinder heads.

Valves.—Two inlet and two exhaust valves are provided per cylinder, operated by overhead cam shafts and rockers. The valves seat direct in the part spherical cylinder heads and their stems are consequently divergent. The valves are made from special high chromium steel forgings, working in phosphor bronze guides.

Cam shaft and rocker mechanism.—The cam shafts are inclosed in steel tubular cases, which are mounted on the top of the cylinders. Each cam shaft is provided with six aluminum bearings which are in halves and bolted together, and two one-piece bearings, one at either end.

To operate the divergent valves, tappets are interposed between the cams and each rocker, the latter being arranged to swing in a plane coincident with or parallel to a plane in which its valve lies.

The cam shafts are machined from 5 per cent casehardening nickel-steel bar, and ground on the bearing surfaces and cam faces. The valve rockers are 3½ per cent nickel-steel forgings machined all over, having hardened ends bearing on the tappets and hardened adjustable end pieces bearing on the valve stems.

Auxiliary gear drives.—The gears for driving the cam shafts and all auxiliaries are driven from the rear end of the crankshaft, through the medium of a spring-controlled friction-damped pinion, so eliminating from all auxiliary drives crank shaft torsional vibrations, and are totally inclosed in a suitable casing. All gears are made from 5 per cent casehardening nickel steel, accurately fitted to shafts running on ball bearings.

Cam-shaft drive.—The cam shafts are driven by means of inclined tubular driving shafts with bevel gear at the upper and lower ends. Out-of-alignment and expansion effects are allowed for by hardened serrated couplings. The driving shafts are supported in ball bearings and the whole totally inclosed in tubular casings.

Pistons.—The pistons are of special aluminum alloy and of the Zephyr type. The advantages of this type of piston are that the crown or head is better supported and the cooling of the piston head is considerably improved.

Five piston rings are provided, arranged as four compression rings above the gudgeon pin and one scraper ring below, at the base of the skirt. The compression rings are prevented from rotation by means of stops.

The gudgeon pins are of 5 per cent casehardening nickel-steel, hardened and ground. A special locking device is used to prevent both axial and rotational movements.

Connecting rods.—The connecting rods are "H" section of the "forked" type, made from 3½ per cent nickel-steel forgings, heat-treated to give a high Brinell, and machined all over to reduce weight variations. A divided white-metal-lined steel bush is gripped by the two caps of the forked rod, the ends of the bush being provided with external grooves which engage corresponding internal grooves formed in the forked rod. The other rod is white-metal-lined and works upon the center portion of the steel bush. The small ends of both rods are fitted with "floating" phosphor bronze bushes. All bearings are positively lubricated under pressure.

Crank shaft.—The six-throw crank shaft is machined from a nickel chrome steel forging, all the journals and crank pins being bored for lightness and to convey lubricating oil to all bearings and connecting rods. All crank pins and journals are accurately ground to close limits for size and trueness of diameter. The crank shaft is carried in seven bearings of ample proportions.

Crank case and bearings.—The crank case is of special aluminum alloy, and is made in two halves of box section suitably ribbed to give the necessary stiffness.

The main bearings consisting of divided phosphor bronze shells, white-metal-lined, are held in the two halves of the crank case, long belts passing through both halves adjacent to each bearing.

A shaft driven from the timing gear is arranged along the inside of the lower half crank case and serves to drive three oil pumps—two scavenger and one pressure—together with the water-circulating pump, these pumps being bolted to the bottom of the lower half.

Reduction gear.—A compound epicyclic reduction gear is fitted on the front end of the crank shaft through which is transmitted the drive to the propeller. The annulus driving gear is fixed on the flange of the crank shaft, which rotates the three sets of planet gears round the sun wheel. The latter is the fixed member of the gear and is prevented from rotating by means of a friction anchorage in the form of a multiplate clutch, the plates being anchored to the casing and the sun wheel alternately, and pressed together

by springs. This arrangement limits the maximum torque which may be imposed on the gears, the clutch being designed to slip if a certain torque is exceeded, due, for instance, to periodic stresses set up by propeller vibrations or preignitions.

The gears and other wearing parts are machined from 5 per cent casehardening nickel steel. The planet gears run on ball or roller bearings and are mounted in nickel-steel planet cages which are bolted to the flange of the propeller shaft. The propeller shaft is made of nickel-chrome steel and supported at its inner end in a bearing mounted in the crank shaft and the front end is carried in a roller bearing of ample proportions.

A double-thrust ball bearing is contained in the front end of the epicyclic gear casing to take thrust from the propeller.

The use of an epicyclic reduction gear as arranged on the Rolls-Royce aero engines prevents any reaction from the driving pressures in the teeth of the reduction gears being transmitted to the crank-shaft bearings, and an efficiency is obtained which is far greater than can be got with any other type of gear, owing to the fact that the direction of motion is not reversed; also the gear only converts part of the horsepower. Lubrication of all working parts is effected from engine crank shaft, and the whole gear is totally inclosed in a gear casing which is carried from the front end of the crank case.

Propeller hub.—The propeller hub is a 3½ per cent nickel steel forging, provided with internal serrations engaging similar serrations on the propeller shaft. To locate the hub radially and to secure it against any axial movement two opposed tapers are utilized, one consisting of a split conical phosphor-bronze ring on the propeller shaft, and the other of a conical nut on the extremity of the shaft, each engaging conical seats in the hub. The loose flange is fitted on serrations of the hub, the whole being provided with a number of hollow bolts which pass through the propeller.

Carburetor.—Two carburetors are provided, each supplying one side of the engine. They are of a special Rolls-Royce Claudel Robson type, fitted with needle-valve adjustment by which the flow of gasoline from float chamber to jet may be regulated from the pilot's seat to suit varying altitudes. Special compensating passages are provided in the carburetor which maintain under all conditions the same pressure in the float chamber as in the throat, thereby neutralizing eddy current effects. These passages also enable the float chamber cover to be sealed, thus reducing the risk of gasoline leakage. In addition, drainpipes are arranged below each carburetor to drain away from the engine any gasoline which may be spilled.

Induction pipes.—The induction pipes are of large diameter, formed with bends and water-jacketed adjacent to each carburetor. Suitable nozzles are fitted in each of the manifolds for priming purposes.

Magnetos and ignition system.—Two 12-terminal high-tension magnetos are fitted and are supported on the auxiliary gear case from which they are driven by means of serrated couplings. Incorporated in the latter is a device for enabling a fine and positive adjustment of the ignition timing to be effected. Two spark plugs of approved make are fitted to each cylinder.

Water circulating pump and cooling system.—A centrifugal water-circulating pump of ample capacity is fitted below the bottom half crank case, being driven from the auxiliary shaft through skew gears.

All water-pipe connections consist of rubber joints with a special patented type of clip, allowing of ample flexibility.

Oil pumps and lubricating system.—The lubrication of the engine is on the "dry sump" system, the bulk of the oil being carried in a service tank separate from the engine. Two scavenger pumps and one pressure pump are arranged on the bottom of the lower half crank case, being driven from the auxiliary shaft. The scavenger pumps draw oil from the crank case and deliver it to the service tank and the pressure pump takes its supply from the service tank and delivers it to the main bearings and other parts under suitable pressure.

A compound relief valve regulates the pressure in the main system and also adjusts the pressure of an auxiliary low-pressure system which supplies oil to the hollow cam shafts, their bearings, and drive mechanism.

Control mechanism.—The control mechanisms for ignition, throttle, and mixture regulator are fitted on the engine, but connections between the engine and pilot's seat are not provided by Rolls-Royce (Ltd.), being left to those responsible for the installation of the engine.

Revolution counter and air pump.—An arrangement for driving a revolution counter is mounted on the timing-gear case, the connection being driven at one-quarter crank shaft speed. An air pump for supplying pressure to the fuel tank can be supplied as an extra, being also mounted on the timing-gear case and driven from the timing gear.

Exhaust manifold.—These are fitted one on each side of the engine, being constructed of light sheet-steel pressings, acetylene-welded together. Suitable union attachments are fitted for connecting the manifolds to light steel exhaust pipes.

Engine-starting gear.—An epicyclic starting gear is fitted on the timing-gear case to which is connected a starting handle on one side and on electric motor on the other.

Priming of the induction pipes is effected by the Rolls-Royce priming device, supplied with each engine, which enables a highly atomized mixture of gasoline and air to be injected into the induction pipes. This device is intended to be fitted near the pilot's seat, and connected to the induction pipes by a copper tube, a length of which is supplied for the purpose.

Direction of rotation.—The direction of rotation of the propeller is clockwise as viewed from the propeller end of the engine.

The engine can be used as either a tractor or pusher.

Spanners, tools, and spares.—A complete set of spanners suitable for carrying out any adjustments to the engine, together with a quantity of spare parts, are supplied in tool box with each engine. A set of special spanners and tools such as are required for dismantling and erection are supplied at an extra cost.

Materials.—All materials used in the construction of these engines are produced in exact conformity with Rolls-Royce specifications, which are based on many years' experience with alloy steels and nonferrous alloys. These

specifications embody all the requirements of the standard specifications issued by the British Air Ministry, but are much narrower in their scope and demand greater freedom from impurities, also closely limit variations of heat treatment.

Testing of materials.—All mild and alloy steels are carefully tested in the raw state, every bar and billet being proved by heat-treatment, fracture, and Brinell test, to insure that the raw material is correct to specificiation.

Each individual crank-shaft and propeller-shaft forging is tested separately. Camshafts, connecting rods, etc., are tested in batches, one forging being selected out of each batch of a specified number and after heat treatment are required to pass the following tests:

(*a*) Tensile (static).
(*b*) Stanton (fatigue).
(*c*) Izod single impact (heat-treatment test).

In the case of nonferrous metals, tensile test pieces are taken from every large casting and from every main cast.

Testing of engines.—All engines are tested in accordance with schedule of standard production and type tests as laid down for aircraft engines by the Air Ministry, and are carried out under the supervision of a representative of the Aircraft Inspection Department.

These engines are of a type and design which have been approved by the Air Ministry, who issue air-worthy certificates after the engines have successfully completed the tests referred to.

ROLLS-ROYCE (LTD.).

FEBRUARY, 1922.

Rolls-Royce patents under which the Condor engine is manufactured.

Description.	British patent number and date.	Foreign patents and dates.
Friction damped spring device.	15333/12 July 1, 1912	French, 459514. June 19, 1913. U. S. A., 1088241. June 24, 1913. Canadian, 154188. June 20, 1913.
Pipe clips	104484 Nov. 29, 1916	U. S. A., 1277398. Nov. 20, 1917.
Compensating passages in R. R. C-H. carburetors.	126722	U. S. A. Application No. 217905. Feb. 18, 1918.
Friction anchorage of sun wheel.	129381 Nov. 12, 1917	
Arrangement of three or more radial valves in part spherical cylinder head.	130698 Mar. 18, 1918	French 496491. Mar. 5, 1919. U. S. A. Application No. 295327. Mar. 26, 1919. Canadian, 195352. March 20, 1912. Italy, 174851/83. Mar. 31, 1919.
Copper- titanium-zinc aluminum alloy.	153514 Feb. 25, 1920	French Application No. 140163. Feb. 16, 1921.
		U. S. A. Application No. 446115. Feb. 18, 1921, and others pending.
Copper-titanium aluminum alloy.	153823 Feb. 25, 1920	
Antimony-magnesium-titanium-aluminum alloy.	162467 Feb. 25, 1920	

THE DE HAVILAND COMPANY.

Captain De Haviland has designed several new machines since the war. The most prominent machines that have been constructed are described below.

THE DE HAVILAND 14, DAY BOMBER.

The De Haviland 14, day bomber, is powered with a 650-horsepower Rolls-Royce Condor engine.

The main characteristics of this machine are as follows:

Weight, empty: 4,484 pounds.
Gas, 178 gallons: 1, 280 pounds.
Oil: 160 pounds.
Crew: 360 pounds.
Military load: 1,380 pounds.
Total weight: 7,664 pounds.
Speed at 10,000 feet: 122 miles per hour.
Rate of climb to 10,000 feet: 400 feet per minute.
Length, over all: 34 feet.
Span: 50 feet 5 inches.
Area of wings: 618 square feet.
Gap: 6 feet 5 inches.
Chord: 6 feet 6 inches.

This machine was designed by Captain De Haviland for long-distance day bombing and was gotten out immediately after the war.

The engine is mounted on tubular bearers, which are in turn supported on ply-wood bulkheads, and are very similar to the previous De Haviland types. A large nose radiator is fitted and is completely shuttered.

The oil tank is mounted back of the engine. The gasoline tank is situated right in between the wings immediately back of the engine and in front of the pilot.

Inasmuch as the fuselage is so deep, the gravity tank is formed in the upper part of the main tank, and an ample head of gasoline to the carburetor is assured. Gasoline is fed directly by two independent windmill pumps projected above the fuselage. These can be used in combination, singly, or gravity alone.

The gunner and the pilot are situated immediately back of the trailing edge of the planes and in close proximity to one another. The pilot's armament consists of a Vickers gun mounted on the decking. The gunner's cockpit is provided with a scarf mount and his field of fire is improved to the rear by doing away with the top tail bracing. The tail bracing is accomplished by underslung steel tubes to the bottom of the fuselage.

The instrument board is provided with the Smith gasoline-gauge, which is in the form of a U tube connected with a graduated dial on the instrument board. When it is desired to ascertain the amount of gasoline in the tank, a few strokes on a small hand pump brings the pointer to zero. If the pointer is watched, it will be seen to creep steadily up to a figure which indicates the amount of fuel left. For about 30 seconds the pointer continues upward. For the next reading the pump is again called into service.

In addition to the defensive armament referred to, the De Haviland 14 carries a nest of six 112-pound bombs, carried in two double and two single crates inside of the fuselage ahead of the pilot's cockpit. The fuselage floor is open at the points underneath the crates. To prevent the draft, the openings are covered with sheets of brown paper

which are easily torn by the weight of the bomb. The bombs are normally under the control of the bomber, who releases them by means of a series of toggles on the starboard side of his cockpit. Provision has been made, however, for enabling the pilot to discharge the bombs should necessity arise, by a similar set of toggles in his cockpit.

In this machine the lower longerons are divided into relatively short lengths, the ends of these lengths abutting upon an aluminum block which serves as a base for the ends of two lengths of longerons, one vertical strut, one chassis strut, one cross tube, and divers wiring plates. This is to obviate the danger of crushing the wood at these vital compression points, as has ordinarily been found the case at different times on conventional jobs. The undercarriage is similar to the original De Haviland 4 type. The guard has been placed right back of the main tail skid, of sheet metal, and extends to an extension of the sternpost down to a point underneath the tail trimming king-post. It also serves as an auxiliary tail skid and would prevent danger to the trimming gear in case the tail skid was broken.

The tail planes and wings are of the conventional De Haviland design.

Quantities of these machines have not been built to date.

DE HAVILAND 29 MONOPLANE.

Characteristics:

- Structural weight: 2,687 pounds.
- Weight of wings: 1,110 pounds.
- Weight of machine, empty, with water: 4,200 pounds.
- Weight of machine, fully loaded: 6,600 pounds.
- Area of wings: 440 square feet.
- Area of rudder: 15½ square feet.
- Area of tail plane: 53 square feet.
- Area of elevators: 32 square feet.
- Area of fin: 6½ square feet.
- Total length: 43 feet.
- Span: 54 feet.
- Chord at root: 12 feet 3 inches.
- Chord at tip: 6 feet.
- Tread: 8 feet 9 inches.
- Motor, Napier Lion: 450 horsepower.

The fuselage is constructed of spruce longerons and struts and is covered with three-ply veneer. The fuselage is considerably wider at the bottom than at the top. The main plane is an internally braced monoplane. The wings extend out from the top of the fuselage.

This machine has seating accommodation for 10 passengers inside the cabin. Seats are arranged in two rows along the sides of the cabin, leaving a passageway between the rows. Emergency doors have been provided in the roof to insure the passengers' exit in case of alighting in the water.

The engine mounting is of the detachable unit type. The oil tank is carried under the engine and cooling is taken care of by an engine underslung radiator, as has been used in the DH-18 types. Petro flex gasoline tubes are used throughout the gasoline system. Two gasoline tanks are placed in the leading edge of the wings, one on either side of the fuselage. As ordinarily designed the engine was low enough to allow gravity feed direct to carburetor, but with the new nose it was necessary to install a low-pressure gas system owing to the raising of the engine.

The wings are very heavy and weigh approximately 2½ pounds per square foot. The wing spars are built up of spruce flanges with ply-wood sides, forming a box-spar construction. The flanges themselves are laminated, and consist of three strips of vertical surfaces glued together. These spars are also tapered from root to tip. The ribs are all different in construction and section, on account of the tapering in plan and elevation. The wings are entirely covered with fabric in the ordinary way. The ailerons are of the ordinary type and are slightly twisted after the fashion of most German types of ailerons, near the extremities. No balancing has been provided, although the differential system of aileron control has been provided; that is, the aileron on the low side is not pulled down to such an extent as the high side aileron, thus giving the advantage of greater aileron reaction on the high ailreon side.

All controls work in ball bearings. Cables do not run direct to the elevator king-post but terminate on the cranks of a transverse shaft some distance ahead of the tail plane. From these cranks steel tubes run to the elevators as in the Italian Savoia type. Hinged joints are surrounded with leather protectors and are well greased, practically the same principle as on motor car controls.

The undercarriage is practically of the famous DH-18 type with an Oleo rubber shock absorber unit in the rear leg of the lateral landing gear vees.

As heretofore mentioned, considerable trouble has been experienced with tail controls at low speed, and the machine is very heavy. However, Mr. De Haviland is pursuing the tests of this machine with a view toward developing it and remedying the tail controls in the near future.

The tests on the De Haviland 29 monoplanes are now being carried out, but not much success is being attributed to this type at present.

The first one has crashed, and the main trouble experienced to date has been with proper fore and aft controllability. However, it is hoped by Captain De Haviland to remedy this fault in the near future.

THE DE HAVILAND 34.

The De Haviland Co. has recently gotten out a new type 34 commercial biplane, powered with a 450-horsepower Napier Lion engine.

The main characteristics of this machine are as follows:

- Length, over all: 39 feet.
- Span: 51 feet.
- Height: 12 feet.
- Wing area: 590 square feet.
- Weight of machine, empty, with water: 3,365 pounds.
- Pilot: 180 pounds.
- Useful load—10 passengers with luggage or about 2,000 pounds freight: 2,000 pounds.
- Gas, 80 gallons: 575 pounds.
- Oil, 7.8 gallons: 78 pounds.
- Wireless and electric lighting apparatus: 120 pounds.
- Total weight, loaded: 6,318 pounds.
- Wing loading: 10.5 pounds per square foot.
- Loading per horsepower: 13.8 pounds.
- Cruising speed: 105 miles per hour.
- Duration, at cruising speed: 3½ hours.

This machine follows very closely the general arrangement of the famous De Haviland 18. Its performance is better than the 18 and it has a greater useful load.

The fuselage construction is entirely covered with three-ply veneer and the main passengers' cabin is about 12 feet long, 4 feet wide, and about 6½ feet high. Eight seats are arranged in the main cabin, the ninth being placed opposite the lavatory, and, if desired, the seat next the pilot can be occupied by a passenger, bringing the total capacity up to 10.

The engine installation is similar to the De Haviland 18, of the cantilever type. Its entire mounting is slung by four bolt connections. An underslung radiator is fitted, which can be removed without disturbing the engine or propeller.

Gasoline tanks are situated out, away from the fuselage, underneath the top plane: two independent pressure systems joined to a common junction box and filter.

The wings, tail, undercarriage, etc., are very similar to the 18. The main feature on this machine is the differential aileron movement, first experimented with in the type 29, cantilever monoplane. The idea of the differential control is to get greater angular travel on the high wing aileron or on the wing side that is necessary to exert negative reaction. Ball-bearing controls are fitted throughout. All cables that ordinarily pass through pulleys are attached to sliding, round rods, which slide in strong bearings. These rods are about 18 inches long and thus do away with the chance for wear and tear on the cables that has been so ordinarily prevalent and which has been found to be very dangerous. All the controls are visible and extend on the outside.

The undercarriage is the same as on the 18, with a long shock absorber of about a foot in length in the rear leg of the landing gear V, with an Oleo gear. The whole landing gear can be removed from the machine by merely undoing four bolts.

GLOUCESTERSHIRE AIRCRAFT COMPANY.

MARS I—HIGH-SPEED RACING TYPE.

Particulars:
- Engine, Napier Lion: 450 horsepower.
- Chord, top plane: 4 feet 9 inches.
- Chord, bottom plane: 4 feet 9 inches.
- Gap: 4 feet 9 inches.
- Stagger: 13½ inches.
- Incidence: 1½°.
- Dihedral: 174°.

Areas:
- Wings: 205 square feet.
- Span: 23 feet.
- Flap, bottom wing only: 18 square feet.
- Top fin: 3.5 square feet.
- Bottom fin: 1.7 square feet.
- Rudder: 5.3 square feet.
- Tail: 28 square feet.
- Elevators: 10 square feet.
- Total weight: 2,500 pounds.
- Loading: 12.2 pounds per square foot.
- Loading per horsepower: 5.5 pounds.
- Petrol: 50 gallons.
- Oil: 6 gallons.
- Water: 8½ gallons.

This machine has since had its radiator changed over to the Lamblin type, similar to the one used for the 300-horsepower Renault motor, and gave 17 kilometers per hour more speed. This shows the advantage of substituting Lamblin (2), free-air type radiators instead of the conventional free-air honeycomb-core type that was originally installed on this machine.

The gasoline tank is placed centrally and stream lined directly over fuselage on the upper wing. The fuselage and wings of the machine look very much like a modified Nighthawk, except that it has a single interior plane strut. Pilot James claimed this machine had obtained a speed of 212 miles per hour over a course.

AIRPLANE "MARS" LV SCOUT, WITH 230-HORSEPOWER B. R. 2 ROTARY ENGINE.

Ailerons.—Top and bottom, 9.3 square feet each. Total area, 28 square feet—65 per cent fixed, 35 per cent movable.

Fins.—1 top and 1 bottom; total area, 5¼ square feet.

Rudder.—Balanced type, area, 5½ square feet.

Landing gear.—V type, built of wood with quick release wheels, 700 millimeters by 100 millimeters, and the usual rubber shock absorbers. A hydrovane is fitted in front for landing on water.

Guns.—Arrangement is made to take two Vickers guns lying along the top of fuselage, and firing through the propeller, by means of mechanical or the Constantinesco gear. One thousand two hundred rounds of ammunition are allowed for.

Flying controls.—Single-control stick for operating lateral control and elevators, foot bar for rudder and lever for adjusting tail. Control wires inside the body are arranged to give straight lead to wires.

Total weight.—Total weight of the airplane is 2,210 pounds.

Military load.—Military load is 401 pounds.

Load factors.—Wings: Factor of 7 on front truss and 5 on rear, working stress of 5,000 pounds per square inch for spruce members. Tail: Factor of 1½; load of 30 pounds per square foot. Body: Factor of 5 for front portion and rear portion with landing loads; rear portion also to have a factor of 1½, with 30 pounds per square foot down load on tail. Landing gear and skid: Factor of 4½; provision is made to fit rack to carry four 20-pound bombs.

$$\text{Load per square foot } \frac{2{,}210}{270}=8.2 \text{ pounds.}$$

$$\text{Load per horsepower } \frac{2{,}210}{230}=9.6 \text{ pounds.}$$

The stability of the machine is extremely good and can be flown with hands off the controls. All controls are very positive in action.

MARS III—DUAL CONTROL TWO-SEATER, TRAINING MACHINE.

General design.—A two-seater machine for training purposes, having good stability in all directions and all controls very positive in action.

Performance.—Maximum speed, 125 miles per hour; landing speed, 55 miles per hour; climb to 10,000 feet, 13 minutes; ceiling, 19,000 feet; flight duration, 2 hours.

Engine.—Bentley rotary, 1,300 revolutions per minute, 230 horsepower. The same engine that was used successfully during the World War.

Gasoline tanks.—Two 16½-gallon main tanks, one at each side of the body, near the center of gravity of the machine; one gravity service tank (7 gallons) located between spars in top center section of wings. All tanks made of tinned steel. The carburetor is fed by gravity from the service tank, which obtains its supply from main tanks by means of a Vickers air-driven gasoline pump. Total gasoline capacity, 40 gallons.

Oil tank.—Situated on top of fuselage near engine. Capacity, 8 gallons.

Fuselage.—Wooden structure braced with tie-rods and fork ends, very rigid structure, stream lined off with fabric.

Wings.—Total surface, 270 square feet; spares (top and bottom), 27 feet 11 inches; chord (top and bottom), 5 feet 3 inches; gap, 4 feet 6 inches; angle of incidence, 3°; dihedral angle, 172°.

Ailerons.—Top and bottom, 9.3 square feet each.

Tail plane.—Total area, 28 square feet—65 per cent fixed, 35 per cent movable.

Fins.—One top and one bottom; total area, 5½ square feet.

Rudder.—Balanced type, 5½ square feet.

Flying controls.—Single-control stick for operating lateral control and elevators, foot bar for rudder, lever for adjusting tail plane. All controls are in duplicate.

Load factors.—Wings: Factor of 7 on front truss and 5 on rear, working to stress of 4,000 pounds per square inch for spruce members. Tail: Factor of 1½; load of 30 pounds per square foot. Body: Factor of 5 on front portion and rear portion for landing loads; rear portion also to have a factor of 1½ with 30 pounds per square foot down load on tail. Landing gear: Factor of 4½.

Total weight.—Total weight of aeroplane, fully loaded, is 2,130 pounds. Pilot and passenger, 360 pounds.

Wing loading per square foot $\frac{2130}{270}$=7.9 pounds.

Load per horsepower $\frac{2130}{230}$=9.3 pounds.

MARS 11 SCOUT, SINGLE-SEATER, "HAWK."

General design.—Fast single-seater scout of high performance, extremely sensitive to control and having the best possible facilities for view in all directions, also capable of getting off a gun turret and alighting on the deck of an aircraft carrier.

Performance.—Speed at 1,000 feet, 127 miles per hour; speed at 10,000 feet, 121 miles per hour; speed at 15,000 feet, 113 miles per hour; climb to 15,000 feet, 19 minutes; ceiling, 19,000 feet.

Engine.—Bentley rotary, 230 horsepower.

Gasoline tanks.—Two 16½-gallon main tanks, one at each side of the body at the center of gravity of machine; one gravity service tank (7 gallons) located between spars in top center section of wings. All gasoline tanks are made of tinned steel. The carburetor is fed by gravity from the service tank, which obtains its supply from the main tanks by means of the Vickers propeller-driven gasoline pump. Gasoline capacity, 40 gallons.

Oil tank.—Situated on top of the fuselage near the engine. Capacity, 8 gallons.

Fuselage.—Wooden structure braced with tie-rods and fork ends, very rigid structure, streamlined off with fabric.

Wings.—Total surface, 270 square feet; span (top and bottom), 27 feet 11 inches; chord (top and bottom), 5 feet 3 inches; gap (at right angles to chord), 4 feet 6 inches; wing section, R. A. F., 15; angle of incidence, 3°; dihedral angle, 172°.

Ailerons.—Top and bottom, each, 9.3 square feet.

Tail plane.—Total area, 28 square feet—65 per cent fixed, 35 per cent movable.

Fins.—One top and one bottom. Total area, 5¼ square feet.

Rudder.—Balanced type; area, 5½ square feet.

Landing gear.—V type, built of wood, with 700 millimeter by 100 millimeter wheels and the usual rubber shock absorbers.

Guns.—Arrangement is made to take two Vickers guns lying along the top of fuselage, and firing through the propeller, by means of mechanical or the Constantinesco gear. One thousand two hundred rounds of ammunition allowed for.

Flying controls.—Single-control stick for operating lateral control and elevators, foot bar for rudder and lever for adjusting tail, control wires inside body arranged to give straight lead to wires.

Total weight.—Total weight of airplane is 2,180 pounds.

Military load.—Military load is 401 pounds.

Load factors.—Wing: Factor of 7 on front truss and 5 on rear, working stress of 4,000 pounds per square inch for spruce members. Tail: Factor of 1½; load of 30 pounds per square foot. Body: Factor of 5 for front portion and rear portion with landing loads, rear portion also to have a factor of 1½ with 30 pounds per square foot down load on tail. Landing gear and skid, factor of 4½. Provision is made to fit rack to carry four 20-pound bombs.

Load per square foot $\frac{2180}{270}$=8.0 pounds.

Load per horsepower $\frac{2180}{230}$=9.5 pounds.

The stability of the machine is extremely good and can be flown with hands off the controls. All controls are very positive in action.

COMMENTS.

All of the Gloucestershire aircraft designed by Mr. Folland are geometrically similar and have the same identical characteristics of construction and as many interchangeable parts as consistent in practice. These machines are all very similar to the Nieuport Nighthawk, Nieuport Goshawk, and Ses-5 series of airplanes. Mr. Folland was largely instrumental in the design of all these ships.

HANDLEY PAGE.

The most interesting thing about the Handley Page Co. is still their slotted wing. The company is still building large machines, and a good description of one of their latest models for commercial work is given below.

HANDLEY PAGE WING.

Mr. Handley Page's slotted air foil has been installed on a De Haviland 9 and also on a monoplane, using a DH-9 fuselage, landing gear, and empennage. The theory of the slotted wing is not yet susceptible of complete mathematical treatment, but the effect can be dealt with in qualitative fashion.

The lift on any plane is due to combined effect of a suction on the upper surface and a pressure underneath. While pressure on the underneath side increases continually with increasing angle, the suction on the upper surface reaches a critical angle when between 10° and 15° angle of inclination of the chord line of the plane to the horizontal. After this angle is reached, steady flow of the air is broken and burbling results. To avoid this effect and to obtain a continuous increase of the suction effect on the upper surface of the plane to much larger angles than 15°, the slotted plane was devised.

In its simplest form it consists of a narrow slot extended transversely across the plane in the direction of the span. It has a wide opening on the undersurface connected to a narrow exit in the upper surface of the plane. The exit is controlled by a hinged flap extending all along the leading edge of the air foil section and is controlled manually from the pilot's cockpit.

This operates by introducing a new live air stream to the upper surface of the plane and prevents the burbling state. It also allows a suction effect on the upper surface of the plane to continue to a larger angle than before with a consequent higher maximum lift plane. The performance of this air foil has been to effect landing speed that is much lower with a given wing area than we have been ordinarily obtaining with the conventional air foil.

The slot arrangement is mechanically controlled from the pilot's cockpit by control of a hinged, counter-leading edge, surface of air foil section which controls the width and extent of the slot opening at the will of the pilot.

It is practically impossible to get a good ratio of lift to resistance and high maximum lift with the same section. A good ratio of lift to resistance necessarily means a low value of maximum lift while a high value of the lift coefficient means a low value of the lift to resistance ratio. The Handley Page Co. hoped to realize the combination of both by putting in this variable device which will admit of two different effects of the resulting air flow. It is to effect this combination that the new design, known as the slotted plane, was devised.

The experiments with the De Haviland 9 show an approximate increase of 40 per cent of the lift coefficient with the slot opening. The second machine was a cantilever type plane. When tested out in the wind tunnel this second machine gave a maximum lift coefficient of 0.77 absolute unit unslotted and 1.035 when slotted. The full-size machine was loaded to 11 pounds per square foot, and the machine landed at 43 miles per hour, corresponding to the lift coefficient of 1.17 in absolute units. This high-lift coefficient with the high-lift wings proves, according to Mr. Handley Page, that model results still hold good as with wings of thinner sections. In this machine the opening and closing of the slot was carried out by means of the variation of the auxiliary plane control by a lever beside the pilot. Very equal weight lifted in the same landing speed proves that this new slot device is not heavier than ordinary construction.

Mr. Handley Page is at present working on a torpedo type plane, details of which are not available. This machine is to be equipped with his slotted wing and experiments conducted. On the whole, this wing represents marked departure in high-lift sections and should be experimented with on full-scale models to ascertain the ultimate benefits to be derived from this type.

THE HANDLEY PAGE W 8 B.

The Handley Page W 8 B, equipped with two Rolls-Royce Eagle engines is an interesting commercial development.

The main characteristics of this machine are as follows:

Weight, empty, with water: 7,700 pounds.
Pilot: 160 pounds.
Gas for 3¼ hours: 1,000 pounds.
Oil, 10 gallons: 100 pounds.
12 passengers: 2,160 pounds.
Cargo: 880 pounds.
Total weight: 12,000 pounds.

The performance is as follows:

Maximum speed at ground: 104 miles per hour.
Maximum speed at 500 feet: 101 miles per hour.
Rate of climb at ground: 550 feet per minute.
Service ceiling: 10,000 feet.
Landing speed: 54 miles per hour.
Length: 60 feet.
Span: 75 feet.
Chord: 10 feet.
Gap: 11 feet.
Area of wings: 1,456 square feet.

Gasoline tanks are placed on top of the upper plane, with the resulting advantage of a greatly simplified gasoline system. This obviates the necessity for extensive piping and gasoline pump installation with complicated fuel systems. No rubber gasoline connections are employed. Air Ministry type metal couplings are used throughout. Each tank is provided with a gasoline level indicator of the Clift pattern.

The mounting of the engine is not essentially different from the previous Handley Page types.

Instead of a biplane tail, however, as in the Handley Page 0, 400-type, a single stabilizer and single elevator have been installed in conjunction with a fin and counterbalancing rudder. The ailerons employ the Handley Page aileron leading edge counter-balancing feature.

The large cabin will have accommodation for 12 passengers, and there is a smaller cabin of 70 cubic feet capacity for luggage in the rear. A tip-up seat is situated at the side of the pilot so that, if desired, a mechanic can be carried there.

An adjustable tail is provided so that the pilot can adjust the machine for any conditions of load and speed.

The equipment is made up of wireless telegraph apparatus, two air-speed indicators, two altimeters, two inclinometers, two revolution indicators, two radiator thermometers, two oil-pressure gauges, two gasoline-level indicators, two oil thermometers, two Pyrene fire extinguishers.

The pilot and mechanic sit out in the nose of the fuselage proper. Two two-wheel landing gears are situated on either side of the fuselage underneath the engine mounting proper. The shock absorbers are installed in the front legs of these.

This machine will be used for passenger traffic between London and Paris and on other lines to European points.

THE BRISTOL CO.

The Bristol Co., of England, manufacturers of the well-known Bristol Fighter and a long line of less known military aircraft, are still one of the leading aeronautical manufacturing firms in England. Their new Bristol 10-seater commercial airplane and their Bristol Jupiter engine are two aeronautical accomplishments meriting full description.

The characteristics of the Bristol 10-seater are as follows:

General description.—The Bristol 10-seater airplane is a single-engined tractor biplane, having an inclosed cabin for eight passengers and an open cockpit for pilot and mechanic.

Engine installation.—The 400-horsepower Bristol Jupiter engine is mounted on a readily removable swinging mounting, which gives instant access to the back of the engine and dispenses with any necessity for removing cowling.

A steel fireproof bulkhead is fitted behind the engine and all control connections pass through glands. No gasoline is carried in the body aft of the fire bulkhead.

Saloon.—The saloon is entered through a door aft of the lower plane and seats six of the passengers facing forward in separate chairs, the other two facing aft. The seats are collapsible and when folded project only 5 inches from the saloon sides, leaving a maximum of floor space if it is desired to carry cargo in lieu of passengers.

Windows, which can be opened, are fitted the full length of both sides of the cabin and an emergency exit is provided in the roof. Heating is provided by means of hot-air muffs around the exhaust pipes. Behind the saloon is a lavatory compartment suitably fitted.

The internal dimensions of the saloon available as cargo space when no passengers are carried are: Length 10 feet 6 inches; height at center, 5 feet 9 inches; width, 4 feet.

Pilot's cockpit.—The pilot and mechanic are accomodated in a cockpit between the fire bulkhead and the front spar of the top plane, giving a very fine view. A wireless telephone and telegraph installation is provided for in the cockpit (but not supplied), completely accessible to the mechanic.

Luggage hatch.—Below the pilot's cockpit is a luggage compartment, 4 feet 6 inches long by 4 feet wide by 2 feet 6 inches high, accessible through a trapdoor in the underside of the fuselage.

Gasoline system.—The two main gasoline tanks, of 45 gallons capacity each, are slung under the bottom planes at the inner interplane strut. Gasoline is drawn from either of these tanks by two Vickers centrifugal pumps coupled in series, and delivered through a Vickers hand pump to the carbureters, any surplus being returned through a 10-gallon gravity emergency tank, fitted high up on the fire bulkhead. Smith's capacity gauges for both main tanks are fitted on the instrument board.

Chassis.—The chassis is of the two-wheeled Oleoelastic type. Elastic rings are used for suspension and the elastic carriers have been designed for ready renewal of these rings. The Oleo plungers are fitted with a special type of tapered needle valve to control the passage of the oil through the plunger to give constant oil pressure throughout the stroke of 8 inches.

Flying controls.—Single control of the wheel type is fitted, all cable pulleys being 5 inches diameter.

Tail trimming gear.—The tail incidence can be varied by a lever and quadrant adjacent to the pilot to trim the machine under all conditions of speed and load distribution.

Dimensions.—Span, 57 feet, 6 inches; length, over all, 40 feet, 6 inches; height, 11 feet.

Weights.—Machine, empty, 4,000 pounds; fuel—gasoline, 90 gallons, oil, 6 gallons, 715 pounds; crew (2) at 160 pounds, 320 pounds; passengers (8) at 150 pounds, 1,200 pounds; baggage, 350 pounds; wireless, etc., 65 pounds; total, 6,650 pounds.

Loading.—Weight per horsepower (Bristol Jupiter at 400 horsepower), 16.6 pounds; weight per square foot, 9.3 pounds.

Performances.—Speed at ground level, 112 miles per hour; speed at 5,000 feet, 110 miles per hour. Time to climb to 1,000 feet, 1½ minutes; time to climb to 5,000 feet, 13 minutes.

This machine is being used by the Handley Page Co. on their Paris-London air line. So far the machines have been equipped with the Napier Lion engine. However, they propose as they increase the number of these machines on this line to install the new Bristol Jupiter engines. This machine is a very fine passenger-carrying type and embodies practically the latest conception of pilot location, passenger location, engine installation, and disposition of fuel tanks. The fuel tanks are located underneath the bottom wing so as to obviate any danger of fire in case of a crash. The landing gear has a shock absorber in the rear leg of the landing gear V.

THE BRISTOL JUPITER 400-HORSEPOWER 9-CYLINDER AIR-COOLED ENGINE.

The characteristics of this engine are as follows:

- Bristol Jupiter engine, air-cooled radial: 380 horsepower.
- Code name for telegraphic and other purposes: Jupiter.
- Direction of rotation: Left-hand tractor.
- Number of cylinders: 9.
- Bore: 5¾ inches.
- Stroke: 7½ inches.
- Rated full power at normal revolutions per minute: 380 brake horsepower.
- Normal speed: 1,575 revolutions per minute.
- Maximum speed: 1,625 revolutions per minute.
- Weight: 725 pounds.
- Fuel consumption per brake horsepower hour: 0.6 pint.
- Oil consumption per brake horsepower hour: 0.45 pint.

The engine to be constructed in accordance with general arrangement, detail and installation drawings, supervision sheets, schedule of parts, and material specifications, which shall first be submitted to and approved by the director general of supply and research, and to comply with the following general conditions:

(a) Special considerations must be given in the design to enable periodical inspection, adjustment, and top overhauls to be conducted in a minimum of time and with a minimum of labor (i. e., without removal from machine).

(b) The engine must be capable of functioning satisfactorily at all reasonable inclinations of the machine.

One set of tracings and three complete sets of prints of approved general arrangement and detail drawings, schedule of parts and material specifications drawn up in accordance with standard Air Ministry requirements, together with six prints of installation drawings, enumerating all essential details and dimensions affecting installation to be supplied on placing of contract.

Approval of designs and modifications.—All designs and modifications are to be submitted to and approved in writing by the directorate of research.

Materials.—(a) Materials employed in the construction of the engine are to conform to B. E. S. A. standards and the selected schedule approved by the director of research.

(b) Screw threads for studs and bolts employed in the construction of the engine to be in accordance with those laid down in T. D. I. 532.

Tests of power, gasoline, and oil consumption, slow running.—Supervision of tests, etc.—The engines will be designed to conform to and will be submitted to the conditions of the schedule of standard production and type tests for aircraft engines, dated March 30, 1920.

Fire prevention.—(a) Careful provision must be made for draining the carburetor and intake pipe to prevent the accumulation of gasoline.

(b) Carburetors must be disposed in such a manner that the intake can be led outside the aircraft cowling without interfering with the normal functioning of the carburetor.

(c) To avoid danger from fire, in the event of the carburetor flooding, and popping back occurring, the air intake must be carefully fitted with tight joints not likely to break down through vibration.

(d) No soft-soldered joints are to be used in the gasoline piping of the engine.

(e) Rubber gasoline pipes must not be employed in the engine. No rubber flexible connections may be employed on the engine.

(f) In order to insure the requisite margin of safety, to obviate failure with consequent danger from fire, all exhaust, induction, and air intake piping and joints which would be normally inside the machine cowling must be designed to withstand a pressure of 80, 50, and 25 pounds per square inch, respectively.

Ignition system.—(a) Dual ignition shall be provided for with two spark plugs per cylinder.

(b) Two magnetos, B. T. H. type, A. Q. 9, shall be provided and fitted with an approved form of vernier adjustment to the timing on the gear drive. The magnetos shall be of the latest type and embody all approved modifications.

(c) K. L. G. type F. 12 spark plugs shall be provided (2 per cylinder).

(d) The high-tension cables from the magneto distributors to the spark plugs shall be in accordance with Section I of B. E. S. A. Specification No. 3 E. 1. The plug ends of the leads shall be fitted with terminals of approved pattern.

Carburetor, altitude, and ignition controls.—The carburetor, altitude, and ignition controls are to be interconnected and conveniently brought to a countershaft on the engine, with provision at each end of the countershaft for a connection between the engine and pilot's control lever.

Carburetors.—(a) Adequate provision is to be made for heating the mixture to insure effective vaporization of the gasoline.

(b) A minimum of 35 per cent vacuum control must be provided on the gasoline system to compensate for variation at altitude.

(c) Arrangements are to be provided by interlocking the altitude and throttle control to enable the mixture to be brought to the fully rich position when closing the throttle.

(d) The carburetors must be capable of functioning efficiently at the maker's declared maximum B. H. P. output with a gasoline head range from 12 feet to 18 inches, and to give uniform and even acceleration throughout the throttle range.

Lubricating pipes.—All lubricating pipes of three-eighths-inch bore or less are to be weldless steel. No lubricating pipes under one-fourth inch bore are to be employed. If a smaller flow than a pipe of this size will provide is required, the nipple is to be choked to give the correct oil distribution.

Gasoline and oil connections.—(a) All gasoline and oil connections and controls are to be completed on the engine as far as possible, so that the installation of the engine in the machine is rendered as simple as possible.

(b) All pipes are to be electrically grounded to "earth" in the engine in accordance with D. of R. requirements.

Gasoline pump.—A suitable and accessible drive is to be provided to allow for an engine-driven gasoline pump to be fitted. The flange for mounting and spindle for driving the pumps are to be in accordance with the R. A. F. standard, size No. 2.

Starting arrangements.—Provision is to be made for the use of the Royal Aircraft Establishment type of starter. An approved type of nonreturn valve is to be fitted to the cylinder, and suitable drive and distributing valves incorporated on the engine.

Revolution indicator drive connection.—Suitable drive must be provided for direct connection of the standard flexible shaft, running at one-fourth engine speed, for the revolution indicator.

Exposed drives and wearing parts.—All exposed drives and wearing parts are to be protected from the ingress of fine sand and foreign matter incidental to conditions prevailing under certain climatic conditions.

Port openings.—All uncovered port openings are to be provided with suitable coverings to prevent the ingress of foreign matter during transit and storage.

Slinging of engines.—Suitable provision is to be made by permanent fixtures to the engine body for slinging purposes.

Gun-control gear.—Brackets for carrying two C. C. gun gear generators, with cams for their operation, and the necessary engine attachments and fixings to be supplied and fitted.

Propeller hub.—The propeller hub is to be designed in accordance with B. E. S. A. standard requirements, the dimensions enumerated below being standardized to promote interchangeability.

(a) Diameter of flanges.
(b) Distance between flanges.
(c) Diameter of propeller boss shaft.
(d) Number of bolts.
(e) Diameter of bolts.
(f) Pitch of circle of bolts.

This engine has passed the Admiralty 50-hour dynamometer tests and has shown up very well indeed for an air-cooled engine. It is very light. When one considers its weight of 1¾ pounds per horsepower, it can be readily seen what a stride this engine represents in the aeronautical motor work. The diameter over all of this engine is approximately 50 inches. Of course this makes it rather difficult to cowl in a single-seater pursuit plane and makes quite a large nose.

LUCIFER 100-HORSEPOWER ENGINE.

Another type that the Bristol Co. has developed has been the Lucifer 100 horsepower type with three cylinders of the same size as are used in the Jupiter type. Dual ignition is provided in the Lucifer and the total weight of the engine is about 300 pounds. The normal revolutions per minutes are 1,600. This engine has been designed primarily to provide a comparatively low power unit. The main considerations of the Bristol Co. have been reliability in long life combined with low cost of upkeep and ease of production. No attempt has been made to cut the weight, but to obtain the maximum durability and performance from the engine. The parts have been reduced to a minimum and everything sacrificed for endurance and long life. This motor is not a military type.

THE VICKERS CO.

The Vickers Co.'s main project at the present time is building the Vickers Vimy troop transport. It is a twin Napier engined airplane equipped for carrying 16 troops with their personal field equipment. Most of these ships are going to be used in Mesopotamia. The characteristics of this type are analogous to the Vickers Vimy passenger-carrying type. This machine is now being equipped with Oleo type shock-absorbing landing gear instead of the conventional Vickers Vimy rubber shock-absorbing type.

The Vickers machines are all equipped with the famous Vickers centrifugal gasoline pump, and in case of the failure of this feed the pilot has in reserve a hand gas pump, permitting the replenishing of the gravity tank by the hand operation of his pump.

The Vickers troop-carrier control systems are all compensated by telescopic spring arrangements connected to the control in the cockpit. The fuselage of the Vickers troop carrier is entirely of monocoque construction and the wings and tail surfaces are of the conventional Vickers Vimy bomber construction.

VICKERS 8-SEATER PASSENGER.

The Vickers Co. is getting out an experimental 8-seater passenger-carrying airplane equipped with Rolls Royce Eagle engine. This machine has a monocoque fuselage with the pilot situated at the head of the upper wing, as in the Bristol 10-seater type. The characteristics of this machine are as follows:

Wings, high lift: T 64.
Weight of machine, empty: 3,495 pounds.
Pilot: 180 pounds.
Gasoline (72 gallons): 510 pounds.
Oil (5 gallons): 45 pounds.
Reserve water (2 gallons): 20 pounds.
Wireless apparatus: 100 pounds.
Passengers (8 at 160 pounds): 1,280 pounds.
Baggage (8 at 30 pounds): 240 pounds.
Total weight: 5,870 pounds.

General characteristics:
Length, over all: 37 feet 5 inches.
Height, over all: 14 feet 3 inches.
Span: 46 feet.
Chord: 9 feet 3 inches.
Gap at fuselage: 8 feet 2 inches.
Incidence of main planes: 3°.
Dihedral of top plane: 0°.
Dihedral of bottom plane: 3°.
Area of main planes: 785 square feet.
Loading per square foot: 7.5 pounds.
Loading per horsepower (370): 15.85 pounds.

Estimated performance:
Full speed near seal level: 106 miles per hour.
Climb to 6,000 feet: 13.25 minutes.
Full speed at 6,000 feet: 103.5 miles per hour.
Service ceiling: 10,850 feet.
Landing speed: 42 miles per hour.
Duration at 90 miles per hour at 6,000 feet: 360 miles.

The Vickers Co. is also constructing a number of Vickers Viking amphibian flying boats equipped with Napire Lion engines. They are also constructing an experimental model of a bombardment type with twin Napier Lion engines. It has an all-steel fuselage and landing gear and wooden wings. No characteristics of this type could be obtained, as it is one of the new Admiralty types that is confidential.

It has been satisfactorily operated in experiments to determine the practicability of using the Thames. Several flights have been made upon the Thames and the Seine near Paris. Three passengers may be carried in the open cockpit. The maximum speed is approximately 120 miles per hour. The minimum speed is 52 miles per hour and the cruising speed 82 miles per hour.

The Vickers Viking F-4 is an amphibian flying boat with a better commercial performance than the Viking 3, and is fitted with folding wings which fold forward in order to facilitate housing. The toal weight is 5,600 pounds; and allowing for a pilot, fuel and oil, 1,090 pounds is available for a commercial load. The maximum speed is 119 miles per hour and the cruising speed 90 miles per hour.

Four passengers can be carried, two in the forward cockpit, the third in an aft position where the gunner would ordinarily sit, and the fourth beside the pilot. Alternately, the space provided for passengers can be used for goods.

The Vickers Co. has adapted one of their Vickers Vimy machines as an ambulance plane in accordance with Admiralty specifications for this type. This plane is probably the best interpretation of an ambulance type that has been built by any nation to-day. A complete description of the machine is given under the heading, "Air Ministry ambulance plane specifications," which follows this article in the report.

AIR MINISTRY—DIRECTORATE OF RESEARCH—VICKERS VIMY, MODIFIED FOR USE AS AMBULANCE AIRPLANE.

SPECIFICATION OF PARTICULAR REQUIREMENTS TO ACCOMPANY THE CONTRACT AGREEMENT.

This specification is to be regarded for contract purposes as being part of the contract agreement, and as subject to the same conditions.

1. *General requirements.*—The aircraft is to be a Vickers Vimy commercial type, modified so as to fulfill the duties of ambulance airplane, and is to be generally similar to the experimental Vimy ambulance, except as hereinafter stated.

The aircraft is to be designed to carry the full equipment specified in paragraph 6 of this specification.

The aircraft must have a good degree of positive stability in all directions.

The aircraft must be controllable at all flying speeds. The standard Vimy commercial elevator controls must be so modified as to give increased elevator movement.

The passengers' compartment is to be equipped as specified in paragraph 7 of this specification.

The arrangements for landing and taking-off are to be as specified in paragraph 8.

The aircraft is to be constructed in conformity with the drawings approved by the director of research or his representative.

2. *Power unit.*—The engines to be installed are Napier Lions, of which the following particulars are to be assumed:

(*a*) Weight, dry: 912 pounds.
(*b*) Normal horsepower at 2,000 revolutions per minute: 470.
(*c*) Maximum horsepower at 2,100 revolutions per minute: 487.

The propellers are to be designed so that the maximum revolutions stated at (*c*) can not be exceeded under normal circumstances.

The propellers should also be so designed that the engine revolutions at full throttle, when the aircraft is stationary on the ground, are approximately 1,800 revolutions per minute.

The engine installation is to be in accordance with the requirements of the director of research.

The exhaust manifolds are to be fitted with an efficient silencer.

A plate is to be fitted, in clear view of the pilot, stating the normal and maximum permissible revolutions of the engine, with a warning to the effect that the engine is not to be run at the maxim revolutions as stated at (*c*) for a period exceeding five minutes. The throttle control is to be of gate pattern, of which particulars will be supplied. An instruction plate is to be provided, worded as follows: "The throttle lever must not be moved through the gate except when above 5,000 feet, or in case of emergency."

Tankage, including gravity tank, is to be provided for—

Fuel, 167 gallons.
Oil, 14 gallons.
Reserve water, 4 gallons.

The gravity tank must have a capacity of at least 32 gallons.

Petrol system.—The petrol system is to be in accordance with the drawings approved by the director of research.

Rubber as jointing material is to be eliminated as far as possible from the petrol system. All couplings are to be of all-metal type (Air Ministry pattern).

The petrol feed is to be by approved pumps from the main tanks direct to the carburetors, with a by-pass to a gravity tank, so situated that when the aircraft is flying at its maximum climbing angle there is a minimum effective petrol head of at least 20 inches above the jet level at the carburetors.

The delivery from the pumps to the carburetors must be via an approved release valve to a distributor cock or cocks, so arranged that the following selections can be obtained:

(1) Pumps to carburetors and gravity tank.
(2) Pumps to carburetors only.
(3) Gravity tank to carburetors.
(4) Off.

An overflow pipe of sufficient bore to deal with all excess petrol must be provided from the main tank to the gravity tank.

A petrol flow indicator is to be fitted in this overflow pipe, in a position clearly visible to the pilot.

An auxiliary hand petrol pump of approved design is to be fitted between the main and gravity tanks and must be capable of supplying sufficient petrol to maintain full power. The bore of the main petrol pipes must be such that the flow of petrol sufficient for maintaining full power is exceeded by 100 per cent when the carburetor unions are uncoupled, and the supply is in the condition of minimum head.

A Jettison valve is to be fitted into each of the main petrol tanks.

Cooling system.—The cooling system must be in accordance with the drawings approved by the director of research, and provision is to be made for the fitting of auxiliary radiators, of such size as to make the system suitable for operation in tropical climates, as and when necessary.

The aircraft will be delivered with the standard radiators and the necessary suspension fittings for auxiliary radiators. The auxiliary radiators will be delivered in separate cases at the same time as the airplanes.

3. *Load to be carried.*—The load to be carried on acceptance flight is as follows:

	Pounds.
Crew (2)	360
Attendant (1)	180
Patients (9)	1,440
Wireless equipment	150
Water and tanks (medical)	110
Rations	80
Fitted ice chest	100
Stretchers	40
Electrical equipment	160
Service load	2,600
Petrol, 167 gallons	1,200
Oil, 14 gallons	140
Reserve water, 4 gallons	40
Total load	3,980

4. *Contract performance.*—The contract performance with the aircraft loaded to a total weight of 12,500 pounds and with engine revolutions not exceeding those specified in paragraph 2 (*b*), is to be: Speed at 6,500 feet, not less than 98 miles per hour; climb to 6,500 feet, in not more than 16 minutes; service ceiling, not less than 12,000 feet.

5. *Structural strength.*—The strength of the main structure is to be not less than the following standards when the aircraft is loaded to a total weight of 12,500 pounds: Load factor on front truss with center of pressure forward, 4; load factor on rear truss with center of pressure back, 4; factor in terminal nose dive, 1. The above factors, and the failing strength of the fuselage will be determined by the methods described in the Handbook of Strength Calculations HB. 806.

6. *Equipment.*—The following equipment is to be provided for, and the contractor will be required to supply and fit all parts necessary for its installation, including all necessary wiring, such installation to be in accordance with the general instructions issued by the director of research.

Wireless Equipment: C. W. transmitter type 21; receiver model T. f.: earth system Part I; D. F. for ground use.

Equipment schedule (wireless).

Item.	Reference No.	Description.	Quantity.	Supply.	Fitted by—
1	10/4869 L	Arm swiveling, left-hand.	1	R. A. F. on repayment.	Contractor.
2	10/1753...	Brackets aluminum suspension fitted.	4	....do........	Do.
3	10/570.....	Clamp aluminum floor, 1 inch.	1	....do........	Do.
4	10/124....	Reel, aerial type 3..	1	....do........	
5	10/243....	Roller fitting........ or	1	....do........	Do.
5A	2636...	Bush, steel, 1 inch..	1	....do........	Do.
6	G. 4957..	Saddles, red fiber, 1 line P 3.	6	....do........	Do.
7	G. 6702..	Saddles, red fiber, 2 line P 11.	25	....do........	Do.
8	G. 4954..	Saddles, red fiber, 3 line P 11.......	6	....do........	Do.
9	G. 320....	Terminal earth......	1	....do........	Do.
10	10/216....	Tube Dexine, 1 inch.	1	....do........	Do.
11	G. 1108..	Cable, electric, P 3.. ....yards..	2	....do........	Do.
12	5C/21.....	Cable, electric, P 11 ....yards..	25	....do........	Do.
13	G. 6706..	Cable, electric, pattern 482...yards..	8	....do........	Do.
14	G. 1095..	Cable, electric, P 13 ....yards..	5	....do........	Do.
15	10/1786...	Masts, bentwood, telescopic.	1	....do........	Do.
16	G. 1004..	Cable eyes, 2 BA...	18	....do........	Do.
17	G. 1003..	Cable eyes, 0 BA...	6	....do........	Do.
18	10/2880...	Battery inert, 15-volt.	6	R. A. F........	R. A. F.
19	10/2766...	Box battery, 90-volt.	1	....do........	Do.
20	10/4576...	Case valve transit, 3-valve.	1	....do........	Do.
21	10/736....	Cells, dry, type "R"	3	....do........	Do.
22	10/2789...	Case transit wavemeter, CW No. 3.	1	....do........	Do.
23	10/2051...	Control resistance and voltmeter.	1	....do........	Do.
24	10/117....	Cord telephone with plug.	1	....do........	Do.
25	10/1618...	Generator, H. T. air-driven, 1,500 volts, 150 watts.	1	....do........	Do.
26	10/1303...	Key, transmitting C. W.	1	....do........	Do.
27	5C/243...	Lamp electric Min. E. S. caps, 2.2 volts.	3	....do........	Do.
28	10/1806...	Receiver, model T. F.	1	....do........	Do.
29	10/115....	Receiver, telephone with headgear, 750 ohms.	1	....do........	Do.
30	10/2921...	Transmitter, type 21.	1	....do........	Do.
31	10/1123...	Valves, type "R"..	3	....do........	Do.
32	10/1120...	Valves, type "A"..	3	....do........	Do.
33	10/2562...	Wavemeter, C. W. No. 3.	1	....do........	Do.
34	10/4911..	Weight aerial, C. I. with spring.	1	....do........	Do.
35	10/1998..	Windmill, 24-inch pitch.	1	....do........	Do.
36	10/4589..	Wire aerial, R. 4 ....feet..	300	....do........	Do.

Equipment schedule (wireless)—Continued.

Item.	Reference No.	Description.	Quantity.	Supply.	Fitted by—
37	10/1584...	Generator, hand driven, 1,500-volt.	1	R. A. F......	R. A. F.
38	10/5417...	Accumulator, 6 volts, 37 amp./hr.	1	.....do........	Do.
39	....	Coil, collapsible D. F., complete.	1	.....do.......	Do.

Electrical equipment: Services are to be provided for navigation lights; heated clothing (2); Aldis lamp; R. L. tube; internal lighting; identification equipment; W. T. supply; Holt flares; kettle.

Equipment schedule (electrical).

Item.	Type.	Description.	Quantity.	Supply.	Fitted by—
1	T28153.....	Air screw.........	1	R. A. F...	R. A. F.
2	500 W......	Generator, Mk. III	1	.....do....	Do.
3	No. 3......	Generator cradle..	1	.....do....	Do.
4	....	Generator mounting.	1	Contractor	Contractor.
5	No. 3, Mk. III.	Accumulator......	2	R. A. F...	R. A. F.
6	No. 5, Mk. III.	.....do.........	1	.....do....	Do.
7	No. 2, Mk. III.	Voltage control box.	1	.....do....	Contractor.
8	30. 0. 30....	Ammeter.........	1	.....do....	Do.
9	Lucas......	Switch box No. 8..	1	.....do....	Do.
10	Rotax......	Switch box No. 3..	1	.....do....	Do.
11	P. S. H. T..	Navigation lights..	4	.....do....	R. A. F.
12	....	Navigation light mountings.	4	.....do....	Contractor.
13	1 D. F.....	Identification lights.	2	.....do....	Do.
14	1 U. P., old patent...	Identification switch box.	1	.....do....	Do.
15	New patent.	W/T. switch......	1	.....do....	Do.
16	....	Cockpit lights.....	2	.....do....	Do.
17	Holt.......	Night landing flares, sets.	2	.....do....	Do.
18	....	Multi plug and socket.	4	.....do....	Do.
19	{ 8 amp... { 20 amp...	} Plug and socket, } 2-pin.	{ 1 { 1	} Contractor	R. A. F.
20	250 watt...	Electric kettle.....	1	.....do....	Do.
21	....	Bifurcating box...	1	R. A. F....	Do.
22	....	Inspection lamps..	2	.....do....	Do.
23	As reqd...	Cables, cleats, packing and terminal blocks.	....	Contractor	Do.

Instruments: The following instruments are to be fitted in the cockpit in accordance with the requirements of the director of research. These instruments will be supplied from R. A. F. stocks on payment unless otherwise stated.

Item.	Description.	Number.	Type.	Remarks.
1	Air speed indicator......	1	Mk. IV a..	
2	Aluminum tubing for A. S. I.	5	1/16 inch....	12-foot 6-inch lengths.
3	.....do...................	2	1/4 inch.....	3-foot lengths.
4	Rubber tubing for A. S. I.	2	....	5-foot lengths with screws.
5	Aluminum tube clips for A. S. I............	24	....	
6	T pieces for A. S. I......	2	....	
7	Altimeter..............	1	Mk. Va...	0 to 20,000 feet.
8	Cross level.............	1	...do.......	
9	Revolution indicators...	2	Mk. VI...	On engine nacelle.
10	Flexible drives..........	2	....	9-foot lengths.
11	Radiator thermometers.	2	Mk. I a..	22 capillary.
12	Air-pressure gauge.......	1	Mk. V.....	0 to 5 pounds.
13	Oil-pressure gauge.......	2	Mk. VIIO.	0 to 60 pounds.
14	Petrol level gauge........	......	....	In tanks.
15	Petrol flow indicator....	1	....	T. D. prismatic, Dewrance, contractor supplies.
16	Watch and holder.......	1	Mk. V.....	Fitted by sqds.
17	Lighting set.......sets..	2	Mk. III...	
18	Fire extinguishers.......	2	Pyrene....	Do.
19	Compasses..............	2	253........	Contract loan.
20	Pilot's safety belts......	2	....	

7. *Disposition of crew and equipment.*—The two pilots are to be accommodated in the nose, side by side, and are to be provided with full dual control.

Racks for two stretchers are to be fitted on the side of the cabin opposite to the door.

The racks are to be so arranged that there is sufficient lateral space to allow of lifting the stretchers on the racks without tilting them.

Top racks are to be of sufficient height to allow reasonable headroom to the patients seated under the stretchers.

A door is to be cut in the front of the luggage compartment under the pilot's cockpit, allowing of the loading and removal of the stretchers.

Suitable runners are to be fitted on the floor to facilitate sliding the stretchers into the cabin.

A lavatory pan is to be provided. This must be of approved type fitted with an antisplach device, and a cover which is an accurate fit. The lavatory must not flush into space, but must have an easily removable container. The flushing pump is to deliver 2 pints uniformly distributed round the circumference of the pan, at a pressure of 40 pounds per square inch.

A tank with a capacity of 5 gallons is to be provided for flushing water.

A suitable curtain is to be arranged round the lavatory pan.

A drinking-water tank with a capacity of 5 gallons is to be provided at the forward end of the cabin. The top is to be sufficiently accessible for the filling of chatties and "Sparklet" siphons.

Stowage space is to be provided in lockers under the pilot's cockpit for the storage of 60 pounds of food. The lockers are to have sliding panels giving access direct from the cabin.

An ice chest of "Iceland" pattern is to be fitted under the pilot's cockpit and is to be provided with suitable runners.

Access should be by a hinged front cover, and the cold chamber is to be divided into two parts, one of which is to contain 2-quart size "Sparklet" siphons. and one "Aladdin" gallon heat-retaining jar.

A cupboard and bottle rack is to be provided at the aft end of the cabin.

Nine seats are to be fitted in the cabin. These are to be of deck-chair type with folding arm rests, and are to be arranged to give enough leg room for comfort during a long flight.

The attendant's seat is to be at the forward end of the cabin, and he is to be provided with a folding table for the kettle, etc.

The Triplex windows of the commercial Vimy are to be replaced by gauze and are to be fitted with blinds of sunproof material.

Scoop ventilators are to be fitted at the front end of the cabin, on each side. They are to be so arranged that the slip stream is deflected to give adequate cabin ventilation when the aircraft is stationary on the ground. The inlets are to be covered with jute sacking or other similar material, and a syringe is to be provided for the purpose of spraying the sacking.

As much door space as possible is required for rapid evacuation in case of emergency.

Two axes capable of cutting through the cabin walls are also to be provided, one at each end of the cabin.

The fitting of the medical equipment is to be subject to the inspection and approval of the director of medical services.

8. *Miscellaneous.*—Adequate provision is to be made for towing and handling on the ground.

A sufficient number of holding-down rings are to be fitted to the lower planes for the purpose of securing the aircraft in the open.

As far as possible the aircraft is to be interchangeable with the service type Vimy.

The dope scheme to be used is:

Five coats A. M. A. dope to B. E. S. Specification 2D100.

Two coats protective covering P. C. 12—B. E. S. Specification.

Two coats protective covering V. 84—D. 103.

Red crosses on a white ground are to be painted on wings and fuselage as on the experimental aircraft.

All Class I and II modifications approved for the service Vimy are to be embodied.

The undercarriage is to be moved forward and the tail skid pivot strengthened as on the experimental aircraft.

The following particulars are to be stenciled in a conspicuous position on the side of the fuselage:

Weight bare with water...............	—— lbs.
Fuel and oil..........................	1,340 lbs.
Total maximum permissible flying weight............................	12,500 lbs.

August 17, 1921.

BOLTON & PAUL.

Bolton & Paul built a great number of Sopwith machines during the war, and have now turned their attention to all-metal construction.

Their most interesting machine, however, is a stick and wire machine known as the P-8. It is a convertible passenger, mail, or bombardment machine. Its characteristics follow:

Crew: Pilot and seven passengers.
Mail: 500 pounds.
Engines, 2 Napier Lion, water-cooled, fitted with four-bladed propeller 9 feet 6 inches diameter; performance: 450 horsepower.
Ground speed: 149 miles per hour.
Speed at 10,000 feet: 143 miles per hour.
Speed at 15,000 feet: 138 miles per hour.
Ceiling: 25,000 feet.
Climb to 15,000 feet: 15 minutes.
Weight, machine empty: 5,170 pounds.
Fuel: 840 pounds.
Load: 1,870 pounds.
Total weight: 7,880 pounds.
Load per square foot: 10.5 pounds.
Weight per horsepower: 8.75 pounds.
Gas: 100 gallons.
Oil: 12 gallons.
Endurance, loaded, at 10,000 feet: 2¼ hours.
Span: 60 feet 4 inches.
Length: 40 feet.
Height: 12 feet 4 inches.
Gap: 6 feet 6 inches.
Chord, top: 8 feet.
Chord, bottom: 6 feet 6 inches.
Area, wing: 770 square feet.

This machine was designed in 1918 by the Bolton & Paul Co. and is of the single centralized fuselage type. It has both bottom and upper counterbalanced ailerons. The two Napier Lion engines are set in the lower wings at the first strut station, out from the fuselage.

A wide track twin-wheel landing gear has been provided with the landing gear vees extending from underneath the first lower wing strut station. The axles extend from the wheels and are hinged upward on the bottom fuselage longerons.

The stabilizer, elevators, rudder, and fin are of the conventional monoplane type. This machine has very remarkable performance.

The new twin-motored all-metal machine that is being built by the Bolton & Paul Co. for the Air Ministry is practically identical in physical characteristics with the P-8 except for an extra wheel set forward to prevent nosing over.

SHORT BROS. ALL-METAL PLANES.

The Short Bros. Aircraft Co. are the most important exponents of all-metal construction in England. Their newest ship, called the *Silver Streak*, is typical of their methods, so it will be given a detailed description, which should suffice to explain the practices and principles employed.

"SILVER STREAK" ALL-METAL AIRPLANE.

Characteristics of this machine are as follows:

- Engine, Siddeley Puma: 150 horsepower.
- Area: 370 square feet.
- Span: 37 feet 6 inches.
- Length, over all: 26 feet 5 inches.
- Height: 10 feet 6 inches.
- Gas-tank capacity: 50 gallons.
- Oil: 6 gallons.
- Weight, empty: 1,865 pounds.
- Pilot and 400 pounds of freight, or pilot and passengers—weight fully loaded: 2,700 pounds.
- Maximum speed: 120 miles per hour.
- Cruising speed: 90 miles per hour.
- Climb, 10,000 feet: 11 minutes.
- Range at full speed: 360 miles.
- Range at cruising speed: 450 miles.
- Load per horsepower: 10.5 pounds.
- Load per square foot: 7.5 pounds.

This machine is the only British all-metal machine employing duralumin. The system of all-metal construction in this machine embodies the composite use of duralumin and steel. These metals are best adapted to the particular purposes of airplane construction. Nonrustable steel is employed wherever weight allowance permits of suitable thicknesses being used, combining local and comprehensive strength with a reasonable margin of safety. Steel is used, therefore, for the main spars, compression strut wiring, lugs, flying wires, and in the parts most heavily stressed in the wings.

In the main planes and the tail planes the ribs and covering are of duralumin. All the control levers and the landing gear are of steel.

The wing spars are of steel tubes of standard dimensions and the use of these tubular spars enables a thickness of metal to be used which gives them inherent properties of rigidity and strength. The ribs are cut out of flat sheets and slotted and flanged by press tool operation.

The covering of the planes is made up of separate duralumin panels about 12 inches wide. Any of these can be removed and replaced without disturbing the remainder.

The fuselage is constructed wholly of duralumin. The simple form of fuselage is constructed of flat sheets of duralumin fitted on in different shapes and offering a perfect stream-line surface. No internal bracing wires or small fittings are used. The strength of the fuselage is uniformly distributed over its whole area, in consequence of which concentrated points of stress are avoided. This makes it less vulnerable in vital spots to riddling by bullets or shell fire. It allows of an admirable shape for dealing with bending or torsional stress. The fuselage is stiffened by a complete set of duralumin annular channel ribs economically spaced from nose to tail.

Twenty-five or thirty longitudinal duralumin channel stringers are attached in a radial sense the complete length of the fuselage. This form of longeron allows of a smooth surface around the whole fuselage and also permits a distribution of stress to the entire shell.

The engine compartment is built up of duralumin bulkheads which support a tubular engine bed frame proper.

The undercarriage is a combination of pneumatic springs with Oleo shock absorber, eliminating the use of rubber suspension.

A fireproof bulkhead is mounted between the engine and the pilot's compartment. A nose radiator has been fitted to this machine. As a whole, this all-duralumin fuselage represents a very clean job and a minimum of head resistance.

THE SIDDELEY CO.

The Siddeley Co., of which Maj. F. M. Green is chief engineer, has designed and built the following interesting airplane equipment: First, the Siddeley Siskin single-seater fighter; second, the Siddeley Jaguar, 14-cylinder, 350-horsepower, radial, air-cooled engine; third, the Siddeley Lynx, 7-cylinder, 175-horsepower, radial, air-cooled engine. The manufacturers' descriptions of these two engines and the Siddeley Siskin follow:

SISKIN AIRLPLANE.

[Type, single-seater fighter. Designed and constructed by Sir W. G. Armstrong. Whitworth Aircraft (Ltd.). Engined by Armstrong Siddeley Motors (Ltd.).]

I. *General.*—The Siskin is a type of single-seater fighting airplane originally designed for and supplied to the British Government. It has since been modified and improved as the result of service experience so that it now represents the most advanced design of this type of airplane that has been produced. It is fitted with the Armstrong Siddeley Jaguar, 14-cylinder, radial, air-cooled engine for which the airplane was originally designed. Some of the earlier models were engined with the A. B. C. Dragonfly.

All the experience gained in the Great War has been embodied in this airplane. It is robustly constructed and the detail work has been carried out with extreme thoroughness and care. The landing gear enables it to be used in rough country. It is pronounced by pilots to be the most controllable airplane they have ever flown.

The vision for the pilot is exceptional. The position of the machine guns, two or three of which can be carried, is such that they can easily be controlled and adjusted during flight.

The performance of the airplane, particularly at high altitudes, is an advance over any other machine carrying the same useful load. Its speed and climb, combined with its unusual maneuvering power, render it the most formidable fighting machine yet constructed.

II. *Type.*—The airplane is of the biplane tractor type having the top plane larger in span and in chord than the bottom plane. The surface of the main planes is 260 square feet and the weight fully loaded is 2,200 pounds. The load per square foot is 8½ pounds. The normal horsepower of the engine is 320. It is capable of developing 360 horsepower at a higher speed. The load per horsepower is just under 7 pounds. The fuselage is of steel tube throughout and braced with tie-rods. This construction is patented by the Armstrong-Whitworth Aircraft (Ltd.). No welding is used in the frame. The construction is such that there should be little deterioration except in the case of a bad accident. Should this occur, the pilot is protected to a great extent by the strength of the steel frame which surrounds him. The wings are of wood with hollow spars of ample section. The interplane struts are of steel. The construction is such that the airplane is extremely easy to erect, a minimum of truing up being required.

III. *Airplane controls.*—The pilot controls the airplane by means of a rudder bar and control column in the usual way. Fore and aft trim is governed by a handle at the side of the pilot working an adjustable tail plane. The airplane is stable when trimmed to fly at its normal flying speed and the controls are light and extremely effective.

IV. *Engine installation.*—The Armstrong Siddeley Jaguar engine is mounted on a pressed-steel frame in such a way that it can be withdrawn from the airplane without removing the carburetor or any other of its parts. The engine cowling is of the simplest possible construction and it is so arranged that it remains on the engine when this is dismounted. All ordinary adjustments to the engine can be carried out without removing any of the cowling. A large door is provided on each side of the airplane so that the gear on the back of the engine is completely accessible.

V. *Fuel.*—Gasoline is fed to the engine from the gravity tank on the top of the frame containing sufficient fuel to run the engine for about three-quarters of an hour. The remainder of the gasoline is carried in a tank inside the body from which gasoline is pumped by a wind-driven pump to the gravity tank. By this means the gravity tank is kept full so long as there is gasoline in the main tank. The surplus from the pump drains back into the main tank, first passing a gauge which indicates whether or not it is flowing. The throttle and altitude controls are worked by large levers at the side of the pilot. There is no need to have a lever for the ignition, as this is controlled automatically by a centrifugal governor.

A fireproof bulkhead is mounted between the engine and the gasoline tank and the air intakes of the carbureter are taken well outside the airplane.

VI. *Accommodation for pilot.*—The pilot is placed with his eye in line with the chord of the top plane so that he can see either above or below the plane. By this means he obtains a view of the upper hemisphere which is practically unrestricted. The bottom plane is of narrower chord than the top plane and offers but little obstruction to vision downward. The fuselage is comparatively narrow so that the pilot can get a good view over either side, which is of particular assistance in landing.

VII. *Armament.*—The two main guns can be carried directly over the steel tube longerons of the frame, which are of ample strength to stand the recoil of the guns. A belt box can be fixed across the frame between the two guns with sufficient capacity to take about 2,000 rounds of ammunition. An additional gun, if desired, can be carried on the top plane and this can be arranged so that it is possible to fix it in any position to fire from a few degrees from the horizontal upward. The mounting of the guns makes them particularly accessbile. No armament is ordinarily supplied with the airplane.

VIII. *Load carried.*—The normal load carried by the airplane is 400 pounds, including the pilot but exclusive of fuel and oil. Forty gallons of gasoline and 4½ gallons of oil are carried, which will give an endurance of from one and three-fourths to three and one-half hours according to the speed and altitude.

IX. *Performance.*—Carrying the load specified in the preceding paragraph the speed will be 150 miles an hour near the ground, 144 miles per hour at 10,000 feet, and 130 miles per hour at 22,000 feet. The time to reach 10,000 feet will be 7 minutes; 20,000 feet, 25 minutes.

The greatest height that can be reached carrying full load will be 26,000 feet. The speed at which landings can be made is well under 50 miles an hour.

X. *Landing.*—The airplane is fitted with a patent landing gear which is specially designed to enable the pilot to make safe landings at slow speed without shock to the machine. It is possible to land the airplane in small fields, and the shock of landing even on rough ground is so reduced that the life of the airplane is much increased as against the old machines in which more rigid landing gears were used.

The tail skid of the airplane is of robust design and is arranged so that it swivels with the rudder. By this means the airplane can be steered on the ground even at slow speeds with accuracy.

XI. *Structural strength.*—The airplane is designed not only to have a high factor of safety but also to be as safe as possible if damaged by enemy fire. A complete system of bracing is provided to the lower plane in such a manner that the load of any wire can be taken by two other wires if it should become broken. More than this, a wing can be shot away without the airplane collapsing in flight as each plane is supported by independent bracing. A factor of safety of 6 is provided over the normal flying loads.

XII. *Controllability.*—The control of the airplane has been particularly studied in order that the pilot shall be able to obtain the maximum response from his controls with the minimum of effort. The airplane was flown at the British Royal Air Force Aerial Pageant of 1921 in a mock flight as representative of the latest design of fighting scout and its maneuverability was universally considered to be remarkable. This is of the utmost importance to the fighting pilot whose success in an aerial combat depends largely on his power to outmaneuver his opponents.

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It has generally been considered that a maneuverable airplane can not be stable. The Siskin airplane, on the other hand, is stable at ordinary flying speeds, that is to say, it can be flown indefinitely without the use of the control column. This property not only relieves the pilot of anxiety but enables him to have a steady gun platform when firing at his opponent.

XIII. *Equipment.*—

- Two Vickers machine guns and mountings.
- Constantinesco gear.
- Two belt boxes.
- One gun sight.
- Camera equipment, according to requirements.
- Bomb racks and release gear, according to requirements.

The design of the Siskin airplane has been differently conceived than any other craft that was found in Europe. It is a single-bay truss type and the landing axle extends from the outer legs of the center section struts in the top wing to the bottom outer strut points on the lower wing, and the main lift truss wires extend from the bottom wing spar root in the fuselage to the outer strut points on the upper wing. The counter lift truss, however, has been installed extending from the rear leg vees of the landing gear to the bottom outer strut points. The machine in its fuselage and tail unit design resembles very closely the SE–5. This will be understood when it is known that Major Green was one of the original designers of the SE–5.

The whole feature of the truss on the Siskin in its conception was to neutralize as much as possible the effect of gunfire in shooting away a part of the main truss on the machine. For instance, it is quite possible to shoot away the auxiliary lift truss from the landing gear to the bottom wing without crippling the wing truss. It is also possible to shoot away the main truss wires within the wing cellule without completely shattering the wing bracing. It is also possible to shoot away the interplane struts without crippling the main structure. Of course, when I mention the partial crippling of the structure, I mean that enough of the structure has been left so as to allow for sufficient flying to a landing field without injury. It is understood that it would be hardly possible with part of the truss shot away to execute any sharp maneuvers or acrobatics.

This machine is very ordinary in its outline and does not represent the last word in refinement. The guns are placed on the exterior of the fuselage. The machine as a whole is primarily a maneuvering and climbing type, although it has a fairly high speed. The machine's characteristics, by virtue of its speed, climb, and maneuverability, are due principally to its very light motor, thus allowing for a very light machine and giving a light loading per horsepower, giving it a predominance in a measure over other machines of this type, due to its large reserve horsepower. The installation of the motor is very simple and is effectively carried out.

The Admiralty test report on this plane is incorporated in this report.

MANUFACTURERS' DESCRIPTION.

[Armstrong Siddeley Motors (Ltd.). Allied with Sir W. G. Armstrong Whitworth & Co. (Ltd.)]

Radial air-cooled aero engine—175-horsepower, 7-cylinder, type Lynx.

This engine represents the highest point yet reached in the development of the air-cooled aero engine. The design has been the subject of searching tests both on the block and in flight.

The exact price will depend upon the number of engines in the contract. The approximate price will be as follows: Seven-cylinder, 175-horsepower radial air-cooled aero engine, complete with the usual accessories, £950.

The following is the guaranteed minimum performance:

- At normal speed: 1,500 revolutions per minute.
- Horsepower: 175 brake horsepower.
- Gasoline consumption per brake horsepower hour: 0.55 pint.
- Oil consumption per brake horsepower hour: 0.03 pint.
- Weight, complete: 450 pounds.
- Exhaust manifold: 25 pounds extra.

Tests.—Every engine is thoroughly tested before delivery.

Guarantee.—Every engine is sold with a guarantee to replace any parts which fail through defective workmanship or material within a period of six months from the date of delivery.

The Lynx engine is the result of much experimental work. The following are the principal points which are claimed to make it particularly suitable for use on an airplane.

Cooling.—The cooling is beyond criticism and the cylinder design is such that complete freedom from distortion is insured. Such things as broken piston rings or burned valves are unknown.

Oiling.—The oiling system is unique. The big ends of the connecting rods are not only lubricated but are cooled by a generous supply of oil, a small part of which only can get to the cylinders. The engine is particularly clean-running and the oil consumption in flight is well under 1 gallon an hour.

Carburetion.—The carburetion is thoroughly satisfactory and the gas distribution is practically perfect. The engine can be throttled down and opened up rapidly without missing.

Accessibility.—The accessibility is superior to any other engine. Any cylinder can be removed in a few minutes and it is easy to get at all accessories.

Mounting.—The mounting in the airplane will appeal to all airplane designers as a satisfactory solution of a difficult problem. Four aluminum feet are cast on the crank case carried well clear of the engine.

Ignition.—The ignition is by two 7-cylinder magnetos driven off the rear of the engine. Each cylinder is fitted with two spark plugs.

Fuel consumption.—The fuel consumption at full-power test may be as low as 0.525 pint per horsepower hour. The company is prepared to guarantee that the consumption would not be more than 0.55 pint per horsepower hour at full load.

Cylinders.—The cylinders have steel barrels screwed into hemispherical aluminum heads. The latter are thoroughly annealed in order to prevent growth and distortion.

Pistons.—The pistons are of aluminum alloy and are fitted with three compression rings and one scraper ring. The gudgeon pin is of ample size and floats both in the piston and in the connecting rod.

Connecting rod.—The connecting rod system is unique. The master rod proper is separate from the split big end which is designed so that all the rods can be easily dismantled. The wrist pins are floating.

Crank shaft.—The crank shaft is in one piece of exceptional stiffness. It is supported by roller bearings everywhere. The propeller thrust is taken by a single-thrust race, so mounted that it absorbs thrust in either direction. The patented system of double oil circulation cools the crank shaft and big end.

Lubrication.—The lubrication is on the dry sump principle. Any excess of oil is collected in an extension at the bottom of the crank case and pumped back to the tank through a filter. The pressure pump delivers oil to the hollow crank shaft which is drilled with a double system of holes, out and return, so that the oil circulates from the front to the extreme back and to the front again, where it is freely delivered to the timing gear. This system not only keeps the crank shaft and big ends cool but makes the lubrication of the crank pins absolutely sure, as the oil is supplied to them from the out and return lines. A second filter is inserted between the pressure pump and the crank shaft. Both oil pumps and filter are mounted in front of the engine and are consequently quite accessible.

Timing gear.—The timing gear is of the epicyclic type, the cams rotating at one-sixth crank shaft speed. It is mounted entirely on ball and roller bearings. There are two independent cams, for inlet and exhaust. The overhead valves are operated by push rods in front of the engine and rockers mounted on ball bearings.

Induction.—The induction system is composed of pipes radiating from a central chamber containing a fan mounted on the back of the crank shaft. This not only increases slightly the volumetric efficiency but thoroughly mixes the incoming gases and makes for almost perfect uniformity of distribution. The mixture is heated, being jacketed with lubricating oil. This not only serves to heat the mixture but also helps to cool the lubricating oil. The carburetor can be mounted any distance below the rear cover that is desired, by means of a junction piece which can be of any length required. This junction piece can be exhaust jacketed if desired.

Characteristics.—

Number of cylinders: 7.
Bore: 5.
Stroke: 5½.
Normal revolutions per minute: 1,500.
Maximum safe revolutions per minute: 1,650.
Brake horsepower at normal revolutions per minute: 175.
Brake horsepower at 1,650: 190.
Direction of rotation: Left-hand tractor.
Gasoline consumption: 0.525–55 pints per horsepower hour.
Oil consumption: 0.03 pint per horsepower hour.
Weight, dry: 450 pounds.
Weight per brake horsepower: 2.56 pounds.
Diameter over all: 43 inches.

MANUFACTURERS' DESCRIPTION.

[Armstrong Siddeley Motors (Ltd.). Allied with Sir W. G. Armstrong Whitworth & Co, (Ltd.).]

Radial air-cooled aero engine—350-horsepower, 14-cylinder, type Jaguar.

This engine represents the highest point yet reached in the development of the air-cooled aero engine. The design has been the subject of searching tests on the block and in flight.

The exact price will depend upon the number of engines in the contract. The approximate price will be as follows: Fourteen-cylinder 350-horsepower radial air-cooled aero engine, complete, with the usual accessories, £1,550.

The following is the guaranteed minimum performance:

At normal speed: 1,500 revolutions per minute.
Horsepower: 350 brake horsepower.
Gasoline consumption per brake horsepower-hour: 0.55 pint.
Oil consumption per brake horsepower-hour: 0.03 pint.
Weight, complete: 700 pounds.
Exhaust manifold: 40 pounds extra.

Tests.—Every engine is thoroughly tested before delivery.

Guaranty.—Every engine is sold with a guaranty to replace any parts which fail through defective workmanship or material within a period of six months from the date of delivery.

The Jaguar engine is the result of much experimental research work. The following are the principal points which it is claimed make it particularly suitable for use on airplanes:

Cooling.—The cooling is beyond criticism, and the cylinder design is such that complete freedom from distortion is insured. Such things as broken piston rings or burned valves are unknown.

Oiling.—The oiling system is unique. The big ends of the connecting rods are not only lubricated but are cooled by a generous supply of oil, a small part of which only can get to the cylinders. The engine is particularly clean-running, and the oil consumption in flight is well under 1 gallon an hour.

Carburetion.—The carburetion is thoroughly satisfactory and the gas distribution is practically perfect. The engine can be throttled down and opened up rapidly without missing.

Accessibility.—The accessibility is superior to any other engine. Any cylinder can be removed in a few minutes, and it is easy to get at all accessories.

Mounting.—The mounting in the airplane will appeal to all airplane designers as a satisfactory solution of a difficult problem. A steel pressing, which is supplied with the engine, finishes in a flange in which are 16 holes, 25-inch pitch circle. This flange is carried clear of the engine, enabling a simple engine plate to be used.

Ignition.—The ignition is by battery and coil, with a dynamo driven from the engine charging a small accumulator. A switchboard complete with cut-out is supplied.

Fuel consumption.—The fuel consumption at full power on test is as low as 0.525 pint per horsepower-hour. This figure was obtained during an hour's full-speed and full-power trial run at 1,650 revolutions developing 376 horsepower at the conclusion of the test of 50 hours.

Absence of vibration.—The engine is extremely free from vibration at all speeds and on account of its excellent carburetion system is remarkably flexible.

Cylinders.—The cylinders have steel barrels screwed into hemispherical aluminum heads. The latter are thoroughly annealed in order to prevent growth and distortion.

Pistons.—The pistons are of aluminum alloy and are fitted with three compression rings and one scraper ring. The gudgeon pin is of ample size and floats both in the piston and in the connecting rod.

Connecting rod.—The connecting rod system is unique. The master rod proper is separate from the split big end which is designed so that all the rods can be dismantled. The wrist pins are floating.

Crank shaft.—The crank shaft is in one piece of exceptional stiffness. It is supported by roller bearings everywhere. The propeller thrust is taken by a single-thrust race, so mounted that it absorbs thrust in either direction. The patented system of double oil circulation cools the crank shaft and big ends.

Lubrication.—The lubrication is on the dry sump principle. Any excess of oil is collected in an extension at the bottom of the crank case and pumped back to the tank through a filter. The pressure pump delivers oil to the hollow crank shaft which is drilled with a double system of holes, out and return, so that the oil circulates from the front to the extreme back, and to the front again, where it is freely delivered to the timing gear. This system not only keeps the crank shaft and big ends cool but makes the lubrication of the crank pins absolutely sure, as the oil is supplied to them from both the out and return lines. A second filter is inserted between the pressure pump and the crank shaft. Both oil pumps and filter are mounted in front of the engine and are consequently quite accessible.

Timing gear.—The timing gear is of the epicyclic type, the cams rotating at one sixth crank shaft speed. It is mounted entirely on ball and roller bearings. There are two independent cams, for inlet and exhaust. The overhead valves are operated by push rods in front of the engine and rockers mounted on ball bearings.

Induction.—The induction system is composed of pipes radiating from a central chamber containing a fan mounted on the back of the crank shaft. This not only increases slightly the volumetric efficiency but thoroughly mixes the incoming gases and makes for almost perfect uniformity of distribution. The mixture is heated, being jacketed with lubricating oil. This not only serves to heat the mixture, but also helps to cool the lubricating oil. The carburetor can be mounted any distance below the rear cover that is desired by means of a junction piece, which can be of any length required. This junction piece can be exhaust jacketed if desired.

Characteristics.—

- Number of cylinders: 14.
- Bore: 5 inches.
- Stroke: 5½ inches.
- Normal revolutions per minute: 1,500.
- Maximum safe revolutions per minute: 1,650.
- B. H. P. at normal revolutions per minute: 350.
- Maximum B. H. P.: 380.
- Direction of rotation: Left-hand tractor.
- Gasoline consumption: 0.525–55 pints per horse power hour.
- Oil consumption: 0.03 pint per horse power hour.
- Weight, dry: 700 pounds.
- Weight, dry, per B. H. P.: 2 pounds.
- Length, over all: 43 inches.
- Length, engine plate to back of propeller: 25½ inches.
- Diameter, which may be covered by fore cowl: 29 inches.
- Diameter, bearer bolt pitch circle: 25 inches.

SIDDELEY CO.—MAJOR GREEN'S THEORETICAL INTERPRETATION OF A NEW MULTIPLE AIR COOLED ENGINE TYPE.

Airplanes have been fitted with two or more engines with a view to increasing the reliability of the power plant and also increasing the total horsepower by using more engines of a given size. This has been done in two ways, either by arranging for each engine to drive its own propeller, as in the usual twin-engines type, or by providing gearing so that one or more engines can drive the propeller or propellers at will.

The disadvantages of the former type are well known. The chief disadvantage arises from the lack of symmetry—one engine stopped, producing a tendency to turn which has to be counteracted. The resistance of the stopped propeller is also considerable. Again, with an engine stopped, the power available for flight is insufficient to fly properly with full load. Apart from these disadvantages the airplane is apt to get rather complicated in its design and the resistance is likely to be comparatively high, due to having the two power eggs and the main body in separate units.

Several attempts have been made to mount two or more engines in such a way that they can drive one or two propellers. During the latter part of the war the Germans attempted to make airplanes of this type with a variety of arrangements. They were extremely clumsy and heavy and of little practical use. We ourselves have designed and constructed gearing to connect four Puma engines to two propellers for the Bristol Aeroplane Co., which they are now fitting into a large triplane.

This gearing was designed with a great deal of care and the weight of the transmission gear proved to be 1½ pounds per horsepower. It is possible that this could be improved slightly by using higher speed engines, but we do not think that it is likely to be done for less than 1 pound per horsepower at best. There is also the inefficiency of the two bevel reduction gears to consider. When it is remembered that the average commercial aeroplane takes as revenue load about 3½ pounds per horsepower, the loss of 1 to 1½ pounds and the decrease of efficiency would seem to make the use of this type of gear impossible.

The German four-engine airplane which we have had the privilege of examining is fitted with four 6-cylinder water-cooled engines driving onto a single propeller, and mounted in the nose of the airplane. This type of gear is simpler than the type which we made for the Bristol Co., but has been carried out in a clumsy way, and the whole installation obviously weighs so much as to make it impossible. Having studied this and other attempts at a solution of the problem, we have arrived at the conclusion that it is necessary to make engines specially adapted for the purpose if the weight is to be kept within reasonable limits. We have tried various arrangements of power units and have at length arrived at a solution which appears to us to have the following advantages:

(a) The increase of weight of the power unit over the lightest possible arrangement, which is a single-unit radial engine, is about one-half pound per horsepower.

(b) The increase of weight over a V type engine as now used for commercial work is less than one-fourth pound per horsepower.

(c) The loss of efficiency as against any other type of geared engine is practically nil.

(d) The risk of breakdown due to the gearing connecting the engines with the propeller shaft is likely to be remote.

(e) The complete power unit is self-contained and is convenient for mounting in an airplane. The position for the auxiliary units, carburetors, magnetos, exhaust pipes, etc., is convenient, and the whole unit lends itself to the design of a low-resistance airplane.

(f) The power unit consists of three separate engines. When getting off the ground all throttles can be opened wide and the engines will run at their full normal revolutions. When flying level at cruising speed the throttles will be shut until the same revolutions are obtained. Should one engine break down, then if the throttles of the remaining two are opened wide, the full horsepower of each engine will be available. By this means it will be possible to carry on at normal cruising speed with one engine completely broken down.

Description of proposed power unit.—The power unit consists of three V type air-cooled eight-cylinder engines. Each engine is complete in itself except that it has no bottom half crank case. The crank shaft is carried completely from the top half of each engine. The three engines are mounted on a single aluminum casting divided up into three compartments, each compartment forming the oil sump for one of the engines. In the front end of this casting is mounted a short propeller shaft driven by a single spur gear. Each engine drives on this spur gear by a pinion mounted loosely on its own crank shaft. This pinion is driven through a free-wheel clutch keyed to the crank shaft. Any engine can be started up from the propeller by means of a friction clutch combined with the free-wheel clutch. The whole unit is carried in front of the fuselage of the airplane from the back of the main supporting casting.

This installation could be made for a large range of horsepowers. Each unit is now of 650 horsepower. The cylinders are similar to those used on the Jaguar engine, 5-inch bore by 5½-inch stroke. Each engine runs at 1,850 revolutions per minute, while the propeller runs at 750 revolutions per minute. All cylinders, valve gears, pistons, connecting rods, crank shafts, cam shafts, magnetos, and carburetors are identical and interchangeable. The estimate of weight is contained in Appendix 1, below.

Cooling.—No difficulty is anticipated with the cooling of these engines. The air is taken into the middle of the V and flows into the passages between the engines. Owing to the position of the cowling, the air is taken from that part of the propeller which is of a diameter sufficient to make a draft even when the airplane is standing, so that it will be possible to run the engines on the ground without danger. The over-all diameter of the cowling is 4 feet 6 inches. The magnetos and carburetors are completely accessible.

Design of a commercial airplane.—Preliminary designs of a complete airplane have been made in which the multiple unit can be used. The airplane is of the usual tractor type with the pilot seated in front of the top plane. The surface of the main planes is 1,100 square feet. The useful load carried is 3,000 pounds. The load per horsepower is just under 15 pounds with three engines working, and just over 22 pounds with one engine cut out. The load per square foot is a little under 9 pounds. An estimated list of weights is given in Appendix 2.

The airplane will fly straight with one engine completely stopped. It will be possible to get off the ground and to reach a height of about 4,000 feet with full load, using two engines only. The cruising speed of the airplane with two engines at 2,000 feet will be 90 to 95 miles an hour. The gasoline consumption at cruising speed will be 3 miles per gallon. Carrying 12 passengers, this is equal to one thirty-sixth of a gallon per passenger mile.

APPENDIX 1.—*Estimated weights of triple power unit—Three 8-cylinder engines 5-inch bore by 5½-inch stroke.*

	Pounds.
Cylinders, complete, 24, at 21 pounds each	504
Pistons and connecting rods, 24, at 7½ pounds each	180
Bearings, 18, at 7 pounds each	126
Crank shafts, 3, at 85 pounds each	255
Crank case, 3, at 105 pounds each	315
Valve gear, 3, at 40 pounds each	120
Induction pipes, 3, at 20 pounds each	60
Carburetors, 6, at 8 pounds each	48
Magnetos, 6, at 16 pounds each	96
Oil pumps, etc., 3, at 20 pounds each	60
Gear and clutches, 3, at 30 pounds each	90
Main casting, 1, at 150 pounds	150
Main gear, shaft and propeller boss, 1, at 100 pounds	100
Exhaust pipes, 6, at 14 pounds each	84
	2,188

Horsepower at 1,850 revolutions per minute, 650.
Pounds per horsepower of complete unit, 3.35 pounds.

APPENDIX 2.—*Passenger air-plane fitted with triple-power unit—Estimate of weight.*

	Pounds.
Useful load, 14 people and baggage	2,800
Gasoline, oil, and tanks for 4 hours, at 95 miles per hour	1,000
Engine unit complete with propeller and starter	2,350
Main planes, 1,070 square feet	1,200
Landing gear	450
Tail unit	200
Main body, complete with controls and seats	1,400
Sundries	250
	9,650

Horsepower, 650.
Load per horsepower, 3 engines, 15 pounds.
Load per horsepower, 2 engines, 22.5 pounds.
Load per square foot, 9 pounds.

ADMIRALTY PERFORMANCE REPORT ON THE SIDDELEY SISKIN AIRPLANE.

Admiralty report No. M. 260.—Summary of tests of airplane No. C/4541, Siddeley Siskin type, single-seater fighter (high altitude).

Engine, ABC Dragonfly, at 1,650 revolutions per minute: 320 horsepower.
Propeller: Two-bladed.
Diameter 2745, pitch 2710.
Diameter 2740, pitch 2126. Wrongly marked.

Military load: 398 pounds.
Total weight, fully loaded: 2,181 pounds.
Gasoline: 40 gallons.
Oil: 4 gallons.
Weight per square foot: 8.8 pounds.
Weight per horsepower: 6.8 pounds.
Speed at 3,000 feet (1,810 revolutions per minute): 146 miles per hour.
Speed at 6,500 feet (1,790 revolutions per minute): 145 miles per hour.
Speed at 10,000 feet (1,765 revolutions per minute): 143 miles per hour.
Speed at 17,000 feet (1,700 revolutions per minute): 136 miles per hour.
Speed at 20,000 feet (1,660 revolutions per minute): 130 miles per hour.
Climb to 10,000 feet (indicated air speed, 75; revolutions per minute, 1,555; rate of climb in feet per minute, 990): 7 minutes, 50 seconds.
Climb to 17,000 feet (indicated air speed, 69; revolutions per minute, 1,535; rate of climb in feet per minute, 540): 17 minutes, 15 seconds.
Climb to 20,000 feet (indicated air speed, 66; revolutions per minute, 1,515; rate of climb in feet per minute, 350): 24 minutes, 15 seconds.
Service ceiling: 23,800 feet.
Rate of climb: 100 feet per minute.
Estimated absolute ceiling: 25,300 feet.
Greatest height reached: 22,700 feet, 35 minutes.
Rate of climb: 175 feet per minute.

General description.
Type: Single-seater fighter R.A.F. Type 1.
Name of contractor: Messrs. Siddeley Deasy Co.
Seating accommodation: Single.
Engine: Type ABC Dragonfly.
Horsepower, at 1,650 revolutions per minute: 320.
Height, over propeller: 9 feet, 9 inches.
Span: 27 feet, 6 inches.
Length: 21 feet, 3 inches.
Seat: Pilot behind rear center section. Upper plane cut away.
Type of controls fitted: Stick, standard handle.
Undercarriage or float arrangement: Special design incorporated with under king-post bracing of bottom main planes.
Type: Two Oleo shock absorbing struts fitted.
Size of wheels: 700 by 100 millimeters.
Tail plane: Adjustable.
Loading—
Surface of main planes: 247 square feet.
Weight per square foot: 8.8 pounds.
Total weight fully loaded: 2,181 pounds.
Weight per horsepower: 6.8 pounds.
Special features: Chassis and main plane structure.
Armament—
Pilot's gun, two Vickers: 88 pounds.
Ammunition: 90 pounds.
Total gun load: 178 pounds.
Miscellaneous gear—
Changing boxes—
Oxygen apparatus }
Electric heating } 40 pounds.

Military load: 398 pounds.
Gun and reconnaissance loads: 218 pounds.
Crew of 1: 180 pounds.
Empty and gross weights—
Weight of machine bare: 1,463 pounds.
Military load less crew: 218 pounds.
Weight of machine in flying trim, empty (actual weight): 1,681 pounds.
Crew of 1: 180 pounds.
Gasoline, 40 gallons, including 1 gallon as dead weight: 284 pounds.
Oil, 4 gallons: 36 pounds.
Gross weight of machine with full load: 2,181 pounds.
Engine—
Type: ABC Dragonfly.
Maker: Sheffield Simplex.
Maker's series No. and W. D. No. 5050—A 60200.
Lubrication system—
System: Pressure.
Oil maker preferred: Wakefield Castrol.
Maximum revolutions and consumption—
Maximum revolutions permitted: 1,750.
Horsepower at these revolutions: 335.
Gasoline consumption: 0.94 pint per brake horsepower hour.
Oil consumption: 0.027 pint per brake horsepower hour.
Exhaust system—
Open except for leads from Nos. 2 and 9 cylinders.
Separate for carburetor muffles.
Lead of exhaust pipes.
Magnetos—
Number: 2.
Make: A. E. 9TB.
Carburetor—
Number: 2.
Make: Claudel-Hobson H. C. 8.
Size of jets: 700 by 710; pilot's, 230.
Radiators—
Type: Air-cooled radial.
Air screws—
Maker's series No.: A. B. 8979.
Drawing number—
Marked: 2710.
Measured: 2126.
Diameter: 240.5.
Fuel capacity—
Gasoline—
Position in fuselage in front of pilot, pressure: 28 gallons.
Position in top plane, gravity: 12 gallons.
Oil: 4 gallons.
Top plane, span—
Maximum: 27 feet 6 inches.
Mean effective: 6 feet.
Bottom plane span—
Maximum: 20 feet.
Mean effective: 5 feet.
Area, top plane: 155.8 square feet.
Area, bottom plane: 91.4 square feet.

Total area of planes: 247.2 square feet.

Lateral control surfaces—
- Top plane: 8 feet 2 inches.
- Chord: 1 foot 6 inches.
- Area: 24.7 square feet.

Longitudinal control surfaces—
- Tail planes, top: 9 feet 6 inches.
  - Chord: 1 foot 6 inches.
  - Area: 24.8 square feet.
- Elevators, top: 9 feet 6 inches.
  - Chord: 1 foot 3 inches.
  - Area: 11.4 square feet.

Directional control surfaces—
- Fins: 7.2 square feet.
- Rudders, balanced area, 3.95 square feet: 10.7 square feet.

Rigging—
- Thrust line horizontal—
  - Main plane incidence: 4° 35′.
  - Dihedral: 3° 30′.
  - Stagger: 22″.
  - Tail plane incidence—
    - Maximum: 5°.
    - Minimum: 2°.
- Propeller clearance: 7 inches.

Climbing tests.

Standard height.	Time from start.		Rate of climb.	Rate per minute.	Indicated air speed.	Per cent of standard density.	Petrol consumption.
	Min.	*sec.*	*Ft.-min.*				*Gallons per hour.*
Stationary on ground				1,570		102.5	
1,000 feet		37	1,560			99.4	
2,000 feet	1	15	1,500	1,568	78.5	96.3	
3,000 feet	1	53	1,435			93.2	
4,000 feet	2	35	1,380	1,565	78	90.3	
5,000 feet	3	20	1,305			87.4	
6,000 feet	4	10	1,245			84.5	
7,000 feet	5	0	1,180			81.8	
8,000 feet	5	55	1,120	1,560	76	79.2	
9,000 feet	6	50	1,035			76.5	
10,000 feet	7	50	990	1,555	75	74.0	
11,000 feet	8	55	925			71.7	
12,000 feet	10	0	860	1,550	73.5	69.5	
13,000 feet	11	10	800			67.3	
14,000 feet	12	30	730			65.2	
15,000 feet	13	50	670	1,540	71.5	63.0	
16,000 feet	15	25	610			61.0	
17,000 feet	17	15	540			59.0	
18,000 feet	19	5	480	1,530	68.5	57.1	
19,000 feet	21	25	415			55.3	
20,000 feet	24	15	350	1,515	66.5	53.5	
21,000 feet	27	30	280			51.5	
22,000 feet	31	30	220	1,500	63.5	49.8	
23,000 feet	37	10				48.1	
24,000 feet						46.4	
25,000 feet						44.8	
1,000 meters	2	5	1,420	1,568	78	92.4	
2,000 meters	4	40	1,210	1,565	76.5	83.0	
3,000 meters	7	40	1,000	1,555	75	74.5	
4,000 meters	11	20	790	1,550	73	67.1	
5,000 meters	16	10	580	1,535	70	60.1	
6,000 meters	23	15	370	1,515	67	54.0	

Estimated absolute ceiling, 25,300 feet.

Maximum effective height, 23,800 feet.

Maximum height reached, 22,700 feet in 35 minutes, the rate of climb at this height being 175 feet per minute.

Speed tests.

Standard height.	Per cent of standard density.	Gasoline consumption.	Revolutions per minute.	True air speed.
		Gallons per hour.		*Miles per hour.*
3,000 feet	93.2		1,810	146
6,500 feet	83.2		1,790	145
10,000 feet	74		1,765	143½
13,000 feet	67.3		1,740	141
15,000 feet	63		1,720	139
16,500 feet	60		1,705	137
17,000 feet	59.02		1,700	136
20,000 feet	53.52		1,660	130
22,000 feet	49.82		1,620	125

Stability, controllability, etc.—Stability in all directions is satisfactory, except that directionally, with engine on, "rudder" is very pronounced. With regard to longitudinal stability, the tail plane does not exercise a very marked effect, as with the setting "full" forward, machine can be comfortably flown with engine on or off. Controllability and ease of maneuvering necessary for an airplane of this type are excellent. The landing speed is slow and the machine exhibits no bad flying qualities. Diving is steady, there being no tendency to bunt.

Power unit.—Engine installation and gasoline system have proved satisfactory throughout the trials. Attention is drawn to the "spinner," which is built up around the propeller boss and would necessarily require modification for production purposes. Accessibility is normal.

General construction and design.—In general the radical alterations (or additions) made to the standard method of main plane structure are to be commended. The system of underbracing gives the necessary confidence required by a fighting scout pilot. The undercarriage design with the Oleo struts has given no trouble.

Certain detail designs require modification.—1. Fittings on top longerons carrying V center section struts. The modified design fitted after failure of original fittings is satisfactory.

2. Lugs carrying tail-plane bracing. These have shown signs of bending over. It would be advisable to raise the gauge of these, also the size of streamline wire. The bracing has the required factor of safety, but this size wire requires very careful handling. The lower wires and lugs might also get damaged in taxi-ing.

3. Tail-plane adjustment brackets on front spar require modification to eliminate the slackness and the fouling of the vertical fuselage struts when moved. On the port side this strut will need replacement before further flying.

Armament.—Gun trials have not been carried out at this station. The adjustable gun mounting has been carefully examined and warrants proper firing trials. It is very simple and easy to manipulate, and very accessible. Covers should be provided for the guns for high altitude fighting.

T. M. Barlow,
Major, Chief Experimental Officer,
Airplane Experimental Station.

A. T. Shekleton,
Lieutenant Colonel, Commandant,
Airplane Experimental Station.

Martlesham Heath.

PETRO FLEX GASOLINE TUBING.

The Royal Aircraft Co. has conducted tests on Blaisdell petro flex gasoline tubing which has been found to withstand their fire tests, vibration tests, pressure tests, and immersion tests.

The specifications for this tubing are attached.

This report describes various tests on petro flex tubing to obtain data on its suitability for aircraft use. The tubing is made by the Blaisdell Petro Flex Tubing Co. in lengths of 6 feet, with one-half inch diameter clear bore The special feature of the tubing is an inner lining of 10 to 12 tubes of animal gut drawn over each other, without longitudinal or transverse joints and covered with a casing of two and a half layers of doped fabric. The resulting tubing is shaped to a corrugated spiral form of one-fifth inch pitch and reinforced by winding aluminum wire in the spiral groove formed. The following gives a brief résumé of the various tests to which the tubing was subjected.

Flow tests.—The tubing requires a higher pressure to maintain the same flow as through a plain copper tubing of one-half inch inside diameter. The extra pressure is proportional to quantity Q2.2 for the tubing with external reinforcing wire only.

The maximum additional pressure required to maintain flow through a bend of 180° with 9-inch radius is $2\frac{1}{2}$ per cent.

Vibration test.—Tubing satisfactory for 130 hours when filled with paraffin at 4 pounds per square inch pressure and one end vibrated by a cam of three-sixteenths-inch lift rotating at 1,400 revolutions per minute.

Pressure test.—Tubes after vibration test satisfactorily held 50 pounds per square inch pressure.

Fire test.—The original tubing was completely destroyed by an external fire in 90 seconds. This was due to the highly inflammable dope with which the fabric was impregnated. Another batch of tubing in which the fabric was treated with a different dope burned through in periods ranging from 2 to 4 minutes, though in one special test the outside wrapping was only slightly charred after 15 minutes.

Immersion tests.—The tubing is not affected by gasoline or benzole, but the original tubing was pervious to water. The second batch of tubing tested is treated to be impervious to water.

Joints.—The screwed-in joint supplied with tubing satisfactorily withstood the vibration test, and a direct pull of 200 pounds failed to separate the joint from the tubing.

Weights.—The following table gives the weights of a foot length of three types of tubing:

- Petro flex with internal wire, $1\frac{3}{4}$ ounces } Original
- Petro flex without internal wire, $1\frac{7}{16}$ ounces } batch.
- One-half inch inside diameter P. R. tubing (without armoring), $2\frac{1}{2}$ ounces.
- One-half inch inside diameter copper tubing (20 S. W. G. P.), $2\frac{11}{16}$ ounces.

General.—With the exception of the fire test, the petro flex tubing, together with the special joint couplings, gave very satisfactory results. Given better resistance to fire, the tubing would be eminently suitable for aircraft purposes, as, in addition to its lightness and flexibility, it is truly gasoline-resisting.

SPECIFICATION FOR PETRO FLEX TUBING.

Short lengths of tubing for aircraft gasoline pipes.

Layers of gut:

	umber.
Hog—	
Three-sixteenths inch	4
One-fourth inch	4
Five-sixteenths inch	5
Three-eighths inch	6
One-half inch	8
Five-eighths inch	11
Three-fourths inch	14
Horse—	
Seven-eighths inch	3
One inch	3

Cement.—The tubing is cemented with a mixture of special A. S. skin gelatin, glycerin, and formaldehyde.

Canvas.—Three-sixteenths and one-fourth inch, 4 ounces per square yard. Light cotton wing fabric.

Five-sixteenths inch, two complete laps with one-fourth inch, overlap one-sixteenth inch.

Three-eighths, one-half, five-eighths, three-fourths, seven-eighths, and 1 inch, $7\frac{1}{2}$ ounces per square yard. Heavy cotton fabric. Two complete laps with three-eighths inch, overlap one-sixteenth inch.

Glue.—The adhesive medium between the gut and canvas and between the layers of canvas to be a casein cement to B. S. S. 2 V. 2, as applied to hulls and floats (1,000 pounds).

External finish.—The canvas to be coated externally with pigmented oil varnish (red) to B. S. S. 2 X. 1, and after the external reinforcing aluminum wire is in position a coat of seaplane varnish to B. S. S. X. 17 is to be applied externally to the tubing and wires.

External reinforcing wire.—Three-sixteenths, one-fourth, and five-sixteenths inch, bore tubes: Aluminum 17 S. W. G. or copper 18 S. W. G.; pitch $7\frac{1}{2}$ per inch.

Three-eighths, one-half, five-eighths, three-fourths, seven-eighths, and 1 inch, bore tubes: Aluminum 14 S. W. F.; pitch 4 per inch.

The wire is to be clipped off flush with the end of the last groove.

Assembly.—The root diameters of the various sizes to be as follows:

Size.	Root diameter.	Size.	Root diameter.
$\frac{1}{4}$ inch	$\frac{3}{16}$ inch.	$\frac{5}{8}$ inch	$\frac{1}{2}$ inch.
$\frac{5}{16}$ inch	$\frac{1}{4}$ inch.	$\frac{3}{4}$ inch	$\frac{5}{8}$ inch.
$\frac{3}{8}$ inch	$\frac{1}{4}$ inch.	$\frac{7}{8}$ inch	$\frac{3}{4}$ inch.
$\frac{1}{2}$ inch	$\frac{3}{8}$ inch.	1 inch	$\frac{7}{8}$ inch.

The tubing is to have plain ends and the limit on the bore of the plain ends is to be one-sixty-fourth inch minus 0.

The corrugated portion in the center is to be $1\frac{3}{4}$ inches long and equally spaced from each end of the tube.

The over-all lengths of the various sizes to be as follows: Three-sixteenths inch to five-eighths inch, inclusive, 3 inches long. Three-fourths inch to 1 inch, inclusive, 4 inches long.

The beeswax used in manufacture is to be removed from the plain ends of all short lengths of tubing.

Long lengths of tubing for aircraft gasoline pipes.

The above specification applies in reference to material, limits, method of manufacture, except the corrugations, which are continued to the ends of the tubing, the number of layers of gut and the root diameters which are as follows:

Size.	Number of layers of gut.	Root diameters.
Hog:		
$\frac{3}{16}$ inch	4	$\frac{3}{16}$ inch.
$\frac{1}{4}$ inch	5	$\frac{1}{4}$ inch.
$\frac{3}{8}$ inch	8	$\frac{3}{8}$ inch.
$\frac{1}{2}$ inch	11	$\frac{1}{2}$ inch.
$\frac{5}{8}$ inch	14	$\frac{5}{8}$ inch.
$\frac{3}{4}$ inch	3	$\frac{3}{4}$ inch.
$\frac{7}{8}$ inch	3	$\frac{7}{8}$ inch.
Horse:		
1 inch	4	1 inch.

Tubing for ground equipment.

The above specification applies in reference to material (except the internal and external reinforcing wire and number of laps of canvas), limits, method of manufacture.

The external reinforcing wire is to be galvanized-iron wire, 12 S. W. G.

The internal reinforcing wire is to be lead-coated-iron wire, 15 S. W. G.

Canvas, four complete laps, with three-eighths inch overlap, one-sixteenth inch.

The root diameters and corrugations to be the same as for long lengths of tubing.

End connections for ground equipment tubing will be specified as required.

REID CONTROL INDICATOR.

This control indicator is an instrument manufactured by Vickers (Ltd.), and is designed to indicate to the pilot the three possible deviations from a straight course. It is intended for flying in fogs, clouds, or at night. It indicates the speed of the machine, the rate of turn, and the degree of bank of the machine for its rate of turn or rate of side slip.

The instrument gives the necessary control indications required by the pilot to regain control in fog and to maintain a straight course. The strain to a pilot of watching a pointer has been overcome by the use of small electric lamps.

For indicating the bank of a machine the lamps are arranged in semicircular fashion. The top row of lamps is controlled by mercury lights and the bottom row by being synchronized with a gyro. The lights are arranged to operate in accordance with the position of the machine and indicate each deviation. If the machine is turned to the right, the lights in the bottom row indicate outward to the right, and if it side slips to the right, the lights in the top row indicate to the right and outward. The left-hand lights are red; the center lights, white; and the right-hand lights, green. To keep a straight course, the pilot keeps two white lights constant.

The instrument is very sensitive and accurate and has an adjustment for steadying in rough weather. Controls are fitted for putting the instrument completely out of action when not required, and also for adjusting the brilliancy of the lamps.

The face of the indicator is hinged and can be opened easily in the air for inspection or replacing bulbs in case of failure. Spare bulbs are carried inside the instrument.

Approximately 50 sets of these instruments are now being constructed for the R. A. F. and will be given service tests in Mesopotamia in the near future.

SPECIFICATIONS FOR 1,000-HORSEPOWER NAPIER CUB ENGINE.

Number of cylinders: 16.

Arrangement of cylinders: 4 lines on 4 cranks.

Bore: $6\frac{1}{4}$ inches (158.75 millimeters).

Stroke: $7\frac{1}{2}$ inches (190.50 millimeters).

Normal brake horsepower and speed: 1,000 brake horsepower at 1,800 revolutions per minute.

Total swept volume of engine: 3,681.6 cubic inches.

Compression ratio: 5.2 to 1.

Direction of rotation of crank: Anticlockwise viewed from propeller end.

Direction of rotation of propeller: Clockwise viewed from propeller end.

Normal speed of propeller: 752 revolutions per minute.

Type of gear reduction to propeller: Spur gearing.

Lubrication system: Forced to all bearings.

Type of carburetors: Quadruple carburetor case with oil sump.

Mixture control: Hand control.

Fuel consumption per hour: Five pints per horsepower hour.

Type of ignition: Four magnetos.

Direction of rotation of revolution, counterdrive facing driving shaft on engine: Clockwise.

Starting arrangements: Distributor provided for gas starter.

COMMERCIAL AVIATION—LONDON TERMINAL AIRDROME, CROYDON.

I. *Organization.*—The London Terminal Airdrome, Croydon, is a State-owned customs airdrome under the direction of the controller general of civil aviation, and is the principal British air fort for the continental air services. Here aircraft entering or leaving this country can obtain a customs clearance as do ships at seaports.

The airdrome is under the immediate control of a civil aviation traffic officer who is helped by two assistant traffic officers and by wireless, meteorological, and other staff.

The latest types of ground equipment affecting such matters as night flying, meteorological information, signaling, etc., are installed.

Notice board, situated near the customs office, gives full details of machines due to arrive or depart during the day, of those actually in transit and of the times at which airplanes pass over Lympne Airdrome on their way to or from the Continent. A large chart also gives the position of machines in transit, notification of the positions being received continuously by wireless.

A medical orderly is continuously on duty in a fully equipped first-aid dressing station, and the services of a medical practitioner are available at very short notice.

A post office from which letters, telegrams, etc., may be dispatched is situated on the airdrome (near customs office).

II. *Transport services.*—Air transport services to the Continent were inaugurated on August 25, 1919, and have been operated from Croydon Airdrome since March, 1920. These services, which have been carried out by British and foreign companies, have been operated to Paris, Brussels, and Amsterdam.

During 1921 two British companies ran regular services to Paris during the year, and additional British services to Paris and Brussels are sanctioned to begin this spring.

All transport companies operating regular services on the cross-channel routes are in receipt of subsidies from their respective Governments.

In addition to these regular services, special flights for business or private purposes are carried out by British firms to places at home and abroad.

III. *Accommodation.*—(1) Hangars, workshops, etc.: On the west side of Plough Lane, which passes through the station, are hangars, workshops, technical stores, gasoline stores, etc. Certain of the buildings are occupied by Messrs. Handley Page Transport (Ltd.), Messrs. S. Instone & Co. (Ltd.), Messrs. Surrey Aviation Services, Compagnie des Messageries Aeriennes (French), Compagnie des Grands Express Aeriens (French), Koninklijke Luchtvaart Maatschappij (Dutch), and certain other private owners of machines.

(2) Miscellaneous: On the east side of Plough Lane is a garage maintained by Basil S. Poster (Ltd.), and a residential hotel established in Government buildings by Messrs. Trust Houses (Ltd.), for the benefit of travelers, pilots, mechanics, etc.

A level crossing similar to those used on railways is provided over Plough Lane to enable machines to cross from the hangars to the airdrome and vice versa.

(3) Office plots, etc.: Along the main approach to the departure station are situated the passenger and goods offices of the Air Transport and allied companies.

(4) Public inclosure: To enable members of the public to view the arrival and departure of machines on continental service, an inclosure overlooking the landing ground has been provided.

IV. *H. M. customs.*—The customs office is a fully equipped customs clearance station where officers of the customs service are in constant attendance to clear all outgoing and incoming aircraft. Before departure and on arrival from abroad, machines proceed to the continental arrival and departure station, where the passengers and cargo are subjected to the usual customs formalities.

An immigration office, through which all aliens must pass for passport examination, is attached to the customs office and is in charge of the civil aviation traffic officer.

V. *Civil aviation traffic officer.*—This building, which is the headquarters of the civil aviation traffic officer, is immediately beside the customs station in front of the aerodrome and contains various offices required for administration purposes. The duty office is open day and night and records all details of machines landing, arriving, or departing.

VI. *Central control tower.*—Although regular night flying is not yet in operation, a central control tower has been provided. From this point the officer in charge of night flying can control the whole of the night lighting apparatus, and can communicate with machines in the air by means of visual signals or wireless. The tower contains the switches for the electric night landing lights and is connected by telephone with the searchlight posts and wireless station. During foggy weather one of the civil aviation traffic officers is on duty in the tower to bring in machines by means of wireless directions, should the pilot desire such assistance.

VII. *Meteorological office.*—A meteorological office is situated on the aerodrome, from which are issued hourly reports on the weather conditions prevailing on the London to Paris, London to Brussels, and London to Amsterdam routes. These are posted on a notice board at the aerodrome and distributed to the various air transport companies and to the aerodrome wireless station for transmission to machines in the air. Special detail reports to cover any route or time are also issued on demand. Daily forecasts obtained by telephone from the meteorological headquarters at the Air Ministry are also issued.

VIII. *Night flying lights.*—(1) Landing lights: For the purpose of indicating the proper direction in which machines should take off or land by night, landing lights are provided in accordance with the international air convention. These are arranged in the form of two L's, back to back, the short arms of the L's being at right angles to the direction of the wind.

The lights consist of electric lamps below thick glass covers, flush with the ground, so arranged on the airdrome that the L's can be displayed to indicate the prevailing direction of the wind. In the event of a change of wind, the lights can be altered immediately from the control tower to conform with its new direction.

(2) Local pilotage (cone) light: In order to assist pilots in locating the airdrome at night, a new and distinctive form of aerial lighthouse, known as the local pilotage (cone) light has been installed on the airdrome. This light has two parts, one a flashing lamp and the other a brightly illuminated cone, apex uppermost, which is conspicuous from all directions. It is semiautomatic in operation, an electric switch in the control tower actuating it, and is visible from a distance of about 12 miles.

(3) Searchlights: Three 36-inch searchlight projectors, connected by telephone to the control tower, one at each corner of the airdrome, are installed for the following purposes:

To throw upward fixed beams so that at night aircraft may locate the airdrome.

To light up machines which may have broken down on the airdrome and enable work on them to be carried out during the night, and thus "clear" the airdrome by morning.

To aid aircraft to land at night by throwing a widely divergent light across the airdrome.

(4) Obstruction lights: All high buildings overlooking the airdrome, including the wireless masts, are marked with red obstruction lights as a guide to pilots flying at night.

IX. *Pyrotechnic signals.*—Rocket and Very lights are also used for signaling to and from aircraft in accordance with the International Air Convention.

X. *Compass swinging.*—A compass swinging base installed on the airdrome is available to facilitate the correction of compasses and the services of an expert compass adjuster are available day or night.

XI. *Wireless telegraphy, telephony, and direction finding.*—Wireless plays an important part in the service of commercial flying. It provides an efficient and speedy means of communication for:

(1) The distribution of meteorological information.

(2) Messages from one airdrome to another, i. e., notification of arrivals and departures of aircraft, forced landings, etc.

(3) Ground to air signals.

(4) Navigation of aircraft in flight.

The Air Ministry is the center of the meteorological service and receives, by wireless, weather reports from all parts of Europe. These are passed to the meteorological section, where a collective report is prepared and broadcasted by wireless four times daily.

On the British section of the London-Paris route the wireless stations are at the London Terminal Airdrome, Croydon, and at Lympne (Folkestone).

On the French section the wireless stations are at St. Inglevert (near Calais) and Le Bourget, the Paris Terminal Airdrome.

Haren (Brussels) and Soesterberg (Amsterdam) are the Belgian and Dutch stations, respectively.

The only class of message dealt with are those directly concerned with the service of aircraft; personal messages are not accepted.

The installation at Croydon may be regarded as an up-to-date example of wireless apparatus in that it embodies the latest ideas and developments of wireless research in radio telephony, telegraphy, and direction finding.

XII. *Routine.*—On the departure of an aircraft its name and destination are reported to the duty officer, and a message is written by him in the following form:

> Instone G. E. A. S. I., Pilot Jones, 8 passengers, 16 packages, 3 bags mail, left 1635.

If the airplane is going to Paris, the message is addressed to "Commandant, Le Bourget." It is passed by land line to Air Ministry wireless station, from which it is transmitted to Le Bourget. The Croydon station is thus left free to work with aircraft.

The average time taken between the departure of an airplane and the receipt of the wireless message by the commandant, Le Bourget, is 11 minutes.

COMMERCIAL AIRCRAFT TRANSPORTATION BETWEEN ENGLAND AND FRANCE.

Croydon, the main commercial airdrome of England, is situated 12 miles from London. The air lines running between Paris and London operate between Croydon in England and Le Bourget, which is 12 kilometers outside of Paris.

Each passenger is allowed to carry 15 kilograms of baggage and is required to have his passport viséed on arriving at the airdrome. The passengers at each airdrome must also present their hand baggage for customs inspection.

Both Croydon and Le Bourget have meteorological stations. Every hour from 7 a. m. to 6 p. m. wireless weather reports are received from all the different airdromes situated along the line between Paris and London. These are Beauvais, Abbeville, Le Crotoy, St. Inglevert, Lymne, and Tonbridge. These weather reports are reproduced hourly on the meteorological chart which is posted at the gate of the airdrome for general observation and information purposes. They are available for both pilots and passengers. This chart gives the barometric pressures, temperatures, and wind velocities, wind direction, and the nature of the sky—cloud formation, presence of fog, etc.

To render these weather observations for different points more clear, a ground chart representing France and England is placed on the side of this main characteristic chart, indicating the visibility and general weather conditions by colored disks at all the different points. A blue disk indicates a clear sky, a blue and gray disk represents a semiclear sky, a gray disk represents a cloudy sky, a black disk represents rain, a white disk with black spots represents snow, a yellow disk with an arrow represents a mist, a yellow disk with a cross represents a heavy fog, and a red disk represents a storm. Smaller white disks with significant numerals indicate the visibility in kilometers. The direction of the wind is indicated by an arrow pointed in the direction of the wind, and the number of barbs on the tail of the arrow indicate the force of the wind, each one of these barbs representing 2 kilometers. This ground chart and the meteorological table are placed in front of the aerial navigation control office.

The character of the weather, whether rain, storm, or sunshine; the visibility, direction, and velocity of the wind are all thus characterized by the several disks with the indicative arrow and are thumb-tacked to the geographical position on the ground observation point along the route which the plane will fly.

On another chart situated to one side of this meteorological chart are placed small, 1 : 100 scale, tin airplanes with national commercial air-line identification number of the airplane, and located or thumb-tacked at the different points along the route on this map at which these aircraft are situated in their flight from station to station. As the aircraft transport passes over different air ports along the route, between Croydon and Le Bourget, their position is wirelessed to both stations and the position is shown on the board.

All aircraft are operated on schedule time. The schedules are published in a small booklet called Aero Indicator, which is published under the auspices of the Undersecretary of State for Aeronautics and Airplane Transportation Department in France. These time-tables are very similar to train time-tables and are profusely illustrated with maps, instructions, duties, distances between stations, times of arrival and departure, postage rates, express rates, etc. Monthly, a smaller edition of this Aero Indicator is published for distribution, showing any changes of schedule or information given in the larger edition.

GENERAL.

CONCLUSIONS ON TECHNICAL REPORT.

The aeronautical activities of France, Italy, Germany, Holland, and England have been considered in this report from a technical standpoint. An effort has been made to abstain from making any comment in presenting the outstanding features of aeronautical development in each country in order that the development might be shown in an unbiased way.

Based upon experience and the information procured on this inspection trip, some recommendations have been made as to design of airplanes and motors, metal construction, fuel systems, motor mounting, landing gears, wheels and tires, propellers, thermostatic control, bomb racks, Servo motors, and wireless, and a list of equipment which it is believed would be advantageous for the American Government to purchase abroad has been prepared.

In making these recommendations and drawing these conclusions, no attempt is made to discuss relative merit. The facts have been presented as fully as possible and all the information that could be procured has been incorporated. Opinions have been formed after weighing the relative merits of the development in each country.

GENERAL RECOMMENDATIONS.

DESIGN.

Corrections and interpretations should be established as to minimum load strength factors required in all parts of the airplane structure. This would require more accurate knowledge of the unit loads imposed in all the different evolutions of flight for all the different types. This is absolutely necessary for the immediate and efficient design of aircraft from a structural weight standpoint in view of the various and diversified interpretations and assumptions of the different Air Service engineers with respect to their structural requirements.

AIRPLANES AND MOTORS.

We should purchase as soon as possible (in interpretative form to our multimotored bombardment specifications) the latest Junker 4-Liberty motored, all-duralumin, internally braced monoplane for service test, type adaptation purpose, and observation of this type of construction for educational purposes.

The landing gears should be of the Oleo type. Wheel controls should be installed on all multimotored types and all control surfaces should be compensated. Wings and fuselage should be designed in demountable fashion with the minimum number of couplings. The two wing tips should disengage from the centralized wing unit or center section supported to the fuselage and holding the load, power plant, etc. The fuselage should be detachable at the rear of the main wings, this to render more easy ground hand maneuvering and housing in case of repairs or housing in hangars.

An observation and torpedo-carrying type of airplane should be designed for the model "W" McCook Field, engineering division, 750-horsepower type, 18-cylinder engine.

A single-motored night bombardment type should be powered with a 600 Packard or model "W" engineering division type of engine and our future multimotored bombardment types should be designed around the Liberty Packard 600 or model "W" engineering division engines.

The development in a convertible multimotored type of a troop-carrier and ambulance plane should be undertaken as one of our new types.

A pursuit plane should be designed for the Siddeley Jaguar or Bristol Jupiter type engine. This should be of the climbing and maneuverable type, to ascertain at first hand the advantages of adoption of an analogous type of power plant for one of our types of pursuit planes. The design and development of a suitable air-cooled radial engine of 400 horsepower for pursuit planes and having a diameter of about 45 to 50 inches should be hastened. This motor should not weigh over 2 pounds per horsepower and should be further developed with an auxiliary supercharger for high-altitude work.

Further development work should be carried on with the shock-absorbing mount for the 300 Wright motor.

The Rateau type supercharger should be tried on a new pursuit design.

Single-seater armored pursuit planes should be of the monoplane semiinternally braced type. The controls should be designed in such fashion as to make them absolutely separate and independent in their connections with respect to either aileron. They should have independent circuits so as to allow the aviator to disengage either one or the other of the ailerons at will and still have an aileron under control in case of injury by gunfire. The same should be done with the elevators.

METAL CONSTRUCTION.

It will be absolutely necessary for us to develop military airplane types in all-metal construction. Metal airplanes as evidenced in Europe can be classified under the following categories:

1. The Fokker type, embodying welded steel tube fuselage, welded steel tube landing gear, welded steel tube tail surfaces, and wooden wings.
2. The Junker type, embodying duralumin multiple spar wings, steel landing gear, duralumin frame, and duralumin covering for wings, fuselage, and tail surfaces.
3. Dornier type, embodying alloy steel trellis type wing spars with duralumin ribs and duralumin covering, duralumin frame, duralumin covered fuselage and tail surfaces, and duralumin landing gears.

4. Breguet type, embodying duralumin tube and steel fitting fuselage construction, duralumin and steel fitting landing gear, duralumin spar and wooden rib wing construction.

5. Wibault type, embodying duralumin tubing and steel fitting fuselage in Breguet fashion with Breguet type tail. but with steel landing gear, duralumin spars and ribs in fabric-covered wings.

6. Short type, embodying duralumin-covered fuselage with annular duralumin channel ribs and channel stringers, duralumin tail surfaces and wings of alloy steel tube spar, duralumin rib and duralumin-covered construction.

These represent the principal combinations and adaptations of metal construction which are representative of foreign practice and from which we can deduce the best types for our future all-metal construction.

WINGS AND FUSELAGE.

On our training, pursuit, and day observation single-motored aircraft I would recommend the adoption of welded steel tube fuselage, tail surfaces, and landing gear. Mild steel should be used with fabric-covered fuselage and tail surfaces. For the wing constructions I would advocate the construction of wooden wings for experimental purposes. Our development of sheet-metal types of adaptable wings could be carried along in experimental fashion for application to these machines when the wings are fully developed and proven.

However, experiments should be carried out immediately for the development of wings similar to the Wibault all-metal type with fabric covering and the Dornier metal-covered type. In the Wibault system we should employ alloy steel spars, duralumin ribs, and fabric covering. In the Wibault system we would have the experience of developing an all-metal wing with the major stressed parts of alloy steel and an all-metal wing construction with fabric covering. This would give the advantage of ready inspection in the field and in manufacture and would permit changing of fabric covering without detracting from the inherent properties of all-metal construction. In the Dornier system we would have an all-metal wing using alloy steel spars, duralumin ribs, and steel fitting. A fuselage with duralumin covering should be designed. This would be applicable to some of our internally braced construction or in the conventional Pratt truss type. These two types of wings could be applied to any of our military types. The advantage in developing both the Dornier type wing construction and the Wibault type wing construction would be that we would have perfected metal wings both with and without duralumin covering.

The first recommendation is for welded steel fuselages. However, other desirable types of skeleton fuselages should be developed of the duralumin tube and steel fitting type or of the alloy steel tubing type.

On the larger multimotored monoplanes of internally braced construction with metal covering the Junker type of internally braced construction either in multiple spar fashion as in the JL type or in the two-spar internally braced type as in his latest four-motored, passenger-carrying plane which is now being constructed, is recommended. Fuselage should likewise be either of the Junker type of construction or of the duralumin type and steel fitting, alloy steel tube, or welded steel tube types of construction. This is to be absolutely determined with regard to the relative advantages of accessibility, maintenance, shipment, or consideration of housing in the field. If the machines are of such proportions that they are too large to be housed in standard hangars, they should be of the all-duralumin-covered types of construction.

FUEL SYSTEMS.

When practical, gravity gas-tank feed should be used.

All future fuel systems should be provided with an auxiliary hand feed pump of large capacity from service to gravity tank on all bombardment types of aircraft. This would insure replenishment of gravity feed gasoline in case of failure of the fan-driven pumps. Development should be continued on the fan-driven centrifugal type gasoline pumps.

Service gasoline tanks should be detachable on single-seater pursuit aircraft in lieu of the development of satisfactory resistant covered tanks to resist crashes and incendiary and spotlight ammunition.

Gravity gasoline tanks, however, on pursuit planes, should be of the crash-proof type.

The excess gas required under the new specifications for single-seater pursuit planes over that of combat load should be carried in removable tank, absolutely segregated from any internal integral part of the fuselage structure so as to minimize to the greatest extent the excess cargo space to be provided for in the basic structure of the pursuit airplane. This permits advantages of aerodynamic outline and insures better vision. If this is not done, the structural limitation will cut down performance on account of placing the added gas load.

It is recommended that pursuit planes have a total gasoline capacity of three hours with three-fourths of an hour's fuel in a removable tank. This would permit the design of a ship with two and one-fourth hours' basic fuel capacity. The three-fourths hour fuel supply, it is understood, will be in field removable tanks.

If possible, gas tanks should be placed on the main wing on multimotored machines.

MOTOR MOUNTS.

All motor mountings should be of the easily demountable type with a minimum number of connections so as to facilitate the changing of motors in the field.

LANDING GEARS.

Oleo landing gear development should be pushed vigorously and the purchase of several of these Oleo gears for adaptation to some of our existing types will overcome inertia at least in the development of this type. Our designers and engineers in the field would see the practicable adaptation and feasibility of such types as exist abroad.

On large bombardment multimotored types the main chassis wheel should be placed as near the center of gravity

as possible to facilitate handling on the ground by ground crew; and auxiliary wheels to prevent nosing over should be installed immediately forward but not carrying the load of the airplane while taxi-ing.

WHEELS AND TIRES.

New tires and new wheels should be developed for large bombardment type machines for use in soft, sticky, muddy ground.

PROPELLERS.

Experiments toward the simplification of steel propellers should be carried out with a view to making them easier to manufacture. Our first lesson can be well drawn from the Siddeley interpretation of this type with tapered gauge blade construction.

THERMOSTATIC CONTROL.

Thermostatic temperature control should be developed for our future huge multimotored aircraft, employing three or more motors.

BOMB RACKS.

All bomb racks should be inclosed in the fuselage.

SERVO MOTORS.

Experiments should be carried on for the development of Servo motors for aiding in control of huge bombardment multimotored machines of the near future.

WIRELESS.

Wireless cabins should be installed on all our large bombardment types and in passenger-carrying aircraft.

PURCHASE.

Recommendations of articles to be purchased in Europe follow under next heading.

RECOMMENDATIONS OF ARTICLES TO BE PURCHASED IN EUROPE FOR THE UNITED STATES AIR SERVICE EXPERIMENTAL STATION AT M'COOK FIELD.

It is recommended that the following aircraft and articles of aeronautical equipment be purchased in Europe for study and test by our engineering division for the purpose of determining their value for adaptation of principles in the solution of our problems. Negotiations for some of this equipment may already be under way. These purchases should be made after conference with the chief of our engineering division.

France:
- (1) Breguet sesquiplan.
- (2) Wibault bombardment plane.
- (3) 600-horsepower Renault.
- (4) Rateau supercharger for Hispano-Suiza engine.
- (5) Lamblin radiators.

Germany:
- (1) Junkers new monoplane, with 4 Liberty motors.

Holland:
- (1) Fokker observation plane.

England:
- (1) Siddeley Jaguar, 14-cylinder, air-cooled, radial engine.
- (2) Vickers hand fuel pump.
- (3) Vickers centrifugal fan-driven gasoline pump.
- (4) Reid flight indicator.
- (5) Experimental adaptation of Handley Page type wing.
- (6) Cook drift sight.
- (7) Siddeley steel propeller for Liberty engine, DH-4.
- (8) Rolls-Royce Condor, 600-horsepower, 12-cylinder engine.
- (9) Napier Cub, 1,000 horsepower engine.
- (10) Bristol Jupiter.
- (11) Siddeley Oleo landing gear for Martin.
- (12) Bristol Oleo landing gear for XB1A.

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TECHNICAL SUPPLEMENT.

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